229/

ENVIRONMENTAL RESEARCH

RESEARCH AND TECHNOLOGY BRANCH

CAPITAL INVESTMENT CYCLES AND ENVIRONMENTAL PROTECTION

Ontario
Environment
Environnement

05/01/93

CAPITAL INVESTMENT CYCLES

AND

ENVIRONMENTAL PROTECTION

APRIL 1993

ISBN 0-7778-0513-8

CAPITAL INVESTMENT CYCLES AND ENVIRONMENTAL PROTECTION

APRIL 1993

Cette publication technique
n'est disponible qu'en anglais.

Copyright: Queen's Printer for Ontario, 1993
This publication may be reproduced for non-commercial purposes
with appropriate attribution.

PIBS 2291

CAPITAL INVESTMENT CYCLES AND ENVIRONMENTAL PROTECTION (RE 05 550C)

Report prepared for:

Research and Technology Branch
Economics Office
(Policy Development and Intergovernmental Relations Division)
Ontario Ministry of Environment and Energy

Report prepared by:

Ernst & Young

ACKNOWLEDGEMENT AND DISCLAIMER

This report was prepared for the Ontario Ministry of the Environment. The views and ideas expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. The Ministry, however, encourages the distribution of information and strongly supports technology transfer and diffusion.

Any person who wishes to republish part or all of this report should apply for permission to do so to the Research and Technology Branch, Ontario Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5, Canada.

Copyright: Queen's Printer for Ontario
This publication may be reproduced for non-commercial purposes with appropriate attribution.

TABLE OF CONTENTS

Executive Summary 1

1. Introduction 3

2. Methodology 6

3. Environmental Costs – New vs. Retrofit 8

4. Financial Considerations in the Timing of Environmental Investments 25

5. Understanding and Anticipating Investment Cycles in Ontario Industries 28

Appendix 1 - Data Sources 53

Appendix 2 – References 57

Appendix 3 - Interview List 58

Appendix 4 - Data Presented in Graphs 67

Executive Summary

- This study examines several issues related to the optimal timing of environmental protection investments, including:
  - the evidence that exists concerning the extent to which environmental protection costs are lower for new or substantially modified facilities relative to retrofitting existing industrial plants;
  - whether any cost advantages from installing environmental equipment in conjunction with other capital expenditures are outweighed by financing issues;
  - whether there are distinct industry capital investment cycles that could be monitored and taken into consideration in regulatory decisions by the Ministry; and,
  - the types of indicators that could be monitored by the Ministry to enable it to anticipate periods in which an industry will be upgrading or expanding its plants.

- Our research suggests that cost savings could be realized by firms if changes in environmental regulations were timed to coincide with upswings in capital investment spending. In most industries, the costs of retrofitting environmental protection technologies into existing plants exceeds the cost of meeting the same pollution control standards in new or substantially redesigned production facilities. Thus, if new regulatory requirements for a particular sector were enacted as the industry was about to enter a relatively strong period of capital spending, then total costs of meeting new standards could be reduced.

- The costs of retrofitting pollution control equipment to deal with most air and water contaminants appear to be higher than meeting the same standards in new production facilities in all industries. Cost increases are more likely to be present in indoor applications where space limitations create sub-optimal layouts in retrofits. They are also more prevalent in cases where the best available technology entails a process change solution as opposed to an end-of-pipe approach, or where process change can reduce the flows of wastes to be treated.

- There are some instances in wastewater treatment where these factors are not present, and where retrofit costs do not appear to be significantly greater. However, in some sectors, a new operation will generally be more efficient in its use of water, which would reduce the necessary effluent treatment capacity in new or substantially redesigned plants.

- From a cost of financing point of view, companies preferred to meet new environmental regulations during periods of significant upgrading of productive facilities, rather than during lulls in capital spending. Higher financing costs for productive plant and equipment caused by simultaneous environmental requirements do not seem to have been a major consideration for surveyed firms.

- All industries under consideration in this report have displayed a distinct cyclical pattern in investment spending. The existence of such cycles, particularly the upswings, could provide the Ministry with the opportunity to time new pollution control requirements with the building of new production facilities and substantial upgrading of existing operations.

- The report suggests a number of indicators of an impending boost in investment activity in a particular industry, such as the general business cycle, industry profits, industry capacity utilization, and producer prices. Most industries also have less quantifiable factors that affect the capital spending of firms, including technological change, shifts in the mix of customer demand, and international market developments. The report suggests approaches that the Ministry could pursue to monitor and assess investment cycle indicators.

1. Introduction

1.1 Background

The Ministry of the Environment establishes environmental standards and regulations for a wide range of industries. Water pollution standards are being established as part of the ongoing MISA program, and the Clean Air Program will see substantial tightening of regulations regarding airborne contaminants. The Ministry may well be involved in setting timetables in the future for abatement of greenhouse gases, NOx and VOCs, solid waste generation and other pollutants. As a part of this process, the Ministry is involved in assessing the socioeconomic impacts of environmental regulatory change, including the implications for economic performance in the affected industries.

Both regulatory change and environmental investment are a continuing process. With the exception of certain persistent and highly toxic substances, where current policy is to promote as rapid an elimination as possible, economic considerations are taken into account in setting the levels of abatement and/or their timetable for achievement. The Ministry conducts assessments of the economic impacts of various control requirements placed on industry, in order to target abatement efforts in a manner that minimizes the disruption to economic activity in the province. The Ministry is able to be most aggressive in promoting pollution abatement and control where it recognizes that the economic consequences will be the least severe.

Assessing the severity of economic impacts due to tightening regulatory requirements is a demanding analytical task, and one to which the Ministry has devoted considerable resources. This effort has included the examination of alternative methods of industry and firm level financial analysis, work in defining economic achievability, impact analysis relating to specific regulatory changes, for example, associated with MISA and proposed air quality measures, and analysis of the economic impact of environmental protection spending.

One aspect of this issue that has received less attention relates to the issue of timing: i.e. whether there are particular time periods in which the economic and financial impact of tougher control requirements will be minimized for a given industry. This research project, funded under the Ministry's Research Advisory Committee program, examines some aspects of this timing issue.

Four potential ways exist in which the timing of environmental protection investments can alter the impact on a firm's

competitiveness, primarily by affecting the installation costs of environmental protection measures and/or equipment:

1. In many, but not all, cases, environmental protection equipment or processes are most cost-effectively installed at the same time as a major expansion or upgrading of the firm's production processes, rather than as a retrofit in an existing plant. This suggests that, in such cases, the economic costs of environmental regulations will be lower if timed to match the firm's own investment programs. Many jurisdictions impose more stringent requirements on new or substantially modified plants for this reason.

   Firms that face regulations that are not timed with their own capital spending plans, are likely to find that their competitive position suffers due to the added costs of retrofit .

2. Internal sources of capital (i.e. retained earnings) are often less costly than external capital, depending on the tax status of the firm and its security holders. Donaldson (1962) first made the empirical observation that firms preferred internal over external sources of funds. Two alternative explanations for this preference are: 1) the greater tax burden on dividends relative to retained earnings. See, for example, Auerbach (1984); or 2) management's superior information on investment opportunities relative to potential external investors, who discount these investments more heavily. See Myers and Majlaf (1984). This suggests that there are advantages to having environmental protection capital spending coincide with a period in which earnings are high relative to the firm's other investment capital needs.

   During a period of low profits, companies may be forced to look outside the firm to finance environmental protection spending. As a result, firms may face higher financing costs than are implicit in internal capital.

3. Where external sources of capital are used, the firm could face higher capital costs in periods in which it is borrowing heavily or issuing large volumes of new equity, to finance other, non-environmental capital projects. If true, financing environmental protection at the same time as other capital spending might harm competitiveness more than financing in low investment periods.

4. Finally, the present value of any environmental protection costs will be lower the further into the future such costs are incurred. This provides a motivation for firms to seek to delay such costs, even where the near term conditions for undertaking them (e.g. based on point 1 above) would otherwise be favourable.

Note that these four forces will in some cases operate in opposing directions over the course of the business cycle. The peak of the business cycle could coincide with high retained earnings (point 2) and investment in plant modifications (point 1). However, it may also see the firm constrained in terms of total financing (point 3) if the non-environmental capital programs are very intensive. This will be particularly the case for new business ventures. Thus, it is important to understand, from the perspective of Ontario businesses, which of these effects are the most dominant ones.

1.2 Objectives for this Study

This study is intended to address a number of issues related to the optimal timing of environmental protection investments:

1. The study aims to evaluate if environmental protection costs are lower for new or substantially modified facilities relative to retrofitting existing industrial plants. Further, the study tries to assess whether any differences vary by type of environmental protection investment or industry.
2. The study attempts to analyze whether any cost advantages of installing environmental equipment at the same time as productive capital equipment are outweighed by financing issues.
3. After examining any link between productive investment and the optimal timing of environmental regulations, the study evaluates industry capital investment cycles. Specifically, the study asks whether there are cycles that could be monitored and taken into consideration in the Ministry's regulatory decisions. Finally, the study suggests particular indicators that could be monitored by the Ministry to enable it to anticipate periods in which an industry will be upgrading or expanding its plants.

1.3 Organization of this Report

Including this Introduction, this report comprises five Sections and an Executive Summary. Section 2 presents a brief discussion of the methodology we pursued, which was focussed largely on interviews with environmental and financial experts in Ontario industries. Section 3 reviews our findings on the existence of higher costs for retrofitting environmental controls relative to abatement at new or substantially renovated plants. Section 4 reports the results of interviews with finance officers regarding financing and optimal timing of environmental protection over the business cycle. Section 5 provides a brief review of capital investment cycles in key Ontario industries, and makes recommendations to the Ministry on how these can be monitored in setting timetables for pollution abatement.

2. Methodology

The methodology was designed to ensure that its findings were of relevance to the regulation of Ontario industry. Thus, rather than rely primarily on theoretical studies or evidence from other jurisdictions, a key source of evidence was to be discussions with environmental experts in both regulated firms and consulting engineering.

Our workplan incorporated the following steps:

1. Interviews with environmental and/or production engineers both in industry and in consulting engineering firms to discuss cost issues, primarily with respect to new or substantially redesigned production operations. After discussion with the Ministry, the industries covered included pulp and paper, metal mining and smelting, non-metallic mineral products, petroleum refining, industrial chemicals, steel, motor vehicles and parts, metal casting and metal plating.[1] Twenty-six interviews were conducted with respondents from firms in the industries under consideration. Interviews were subsequently done with ten respondents to explore new versus retrofit issues raised in the first round of discussions. In addition, twelve consulting engineers were interviewed on these same topics.

2. Environmental analysts, primarily in the U.S., were contacted, to try to uncover published material, in-house studies, and anecdotal evidence relating to the economic costs of the timing of control orders within investment cycles. We were particularly interested in cost comparisons of installing environmental protection equipment in existing production facilities with the costs of meeting the same standards in newly constructed or substantially modified plants. Additionally, we conducted on-line data base searches of major media and industry publications to round out the information gathering.

3. A review of the assembled literature was undertaken. This literature was surprisingly thin, despite the frequency with which regulators have adopted different standards for new and existing plants. Since few detailed investigations of new versus retrofit costs are available, the favourable treatment accorded existing plants appears to be based only a general impression of such cost factors. Differing standards between new and existing facilities may reflect the stronger influence of existing firms on regulations relative to new entrants, rather than reflecting a large body of new versus retrofit cost studies.

---

[1] Since much of the metal casting and metal plating activity in Ontario is either done by vehicles and auto parts industry or directly supplies this industry, the metal casting and plating discussions have been included in the vehicle and parts material.

4. A review and evaluation of historical data on capital expenditures by industry, to identify the linkages between investment in the industries under study and various market, economic, and financial indicators, including the overall trend in investment by other industries. As part of this effort, industry analysts from banks, firms, and industry associations were contacted to discuss important factors affecting investment in their industries of interest.

5. Interviews with nine financial executives responsible for capital spending decisions. These discussions focussed primarily on the extent to which cost of capital considerations and the availability of internally generated funds has an impact on their preferences for the timing of environmental regulations.

6. Development of recommendations for monitoring new capital spending or movement of the capital investment cycle in industries.

This workplan was not intended to be a comprehensive survey of all environmental and investment issues for each of the industries included in the study. Rather the study team sought to uncover the key issues in each industry, and attempted to suggest factors that were important in several or all sectors.

Table 1 - Interview Program by Industry[2]

Industry	Environmental Managers		Consulting Engineers	Industry Analysts	Finance Executives
	Main	*Follow-Up*			
Industrial Chemicals	4	2	4	2	1
Metal Casting	2	3			1
Metal Plating	2		3		
Mining/Smelting/Refining	3	1	2	2	3
Non-Metallic Minerals	4	1	1	1	
Petroleum Refining	2	1	3	1	1
Pulp and Paper	3	1	5	3	1
Steel	4	1	2	1	2
Vehicle Assembly/Parts	2		2		
Total	**26**	**10**	**12**	**7**	**9**

2 The figures in the consulting engineers and industry analysts columns do not add to the totals shown because some interviewees had knowledge of more than one industry.

3. Environmental Costs – New vs. Retrofit

3.1 Introduction

In this section, we explore the extent to which the costs of achieving a particular environmental standard are higher when retrofitting at an existing plant than when constructing a new or substantially modified plant. We find that in most, though not all, cases there are higher costs, often substantial ones, associated with retrofit environmental controls.

These costs arise in two ways. First, a new or substantially modified plant often can adopt a more up-to-date production process that is inherently cleaner than existing plants. This reduces the need for, or increases the efficiency of, end-of-pipe control systems. Second, even where the same end-of-pipe treatment processes are used in both cases, an existing plant is often poorly designed for such add-ons, and this results in higher capital or operating costs.

In the next section, we review the types of retrofit costs that have been found to be generally present in a wide range of environmental control situations. We then turn to the results of our discussions with individual industries in Ontario on this issue.

3.2 Sources of Varying Retrofit Costs[3]

A particular environmental protection investment is unique, and it is difficult to generalize about the source of any added retrofit costs. However, several factors can be identified that may cause retrofit costs to vary from expenditures incurred in meeting the same control standard in a new production process.

Auxiliaries represent a very common source of extra costs in retrofit applications, according to engineers interviewed for this study. In air pollution control, the layout of existing facilities may necessitate extra duct work, elbows, dampers, and air movement equipment that might not be necessary in a plant designed with the treatment system in mind at the outset. Additional needs for piping, insulation, and painting are the waste water equivalents of extra duct work in air pollution control, and again are a frequently cited added cost in retrofits.

3 Some of the material in this section is adapted from a similar discussion in the *Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, 1990.

Construction costs in retrofit applications are often higher, due to the need to work around existing equipment. The handling of the control system may be complicated due to the difficulty in getting a crane into the site. This factor could be particularly significant if the device must be placed on a roof with a helicopter or crane.

Physical space limitations can also add to construction costs. If a firm does not have substantial space to work with – either installing a control system inside or outside a plant – then extra retrofit costs may be incurred due to sub-optimal layout of control equipment or the need to purchase adjacent land. This factor was often mentioned in our retrofit cost discussions with plant engineers.

Installing a control system to fit into an existing operation also necessitates added engineering and design efforts, which may be a partial duplication of the design efforts undertaken when the production facility was constructed.

An often overlooked area of higher costs for retrofitting is associated with the need to shutdown plant operations. If a shutdown is necessary during a retrofit then revenue is lost due to lower production. These are opportunity costs that would not be present for a new facility, or a plant already shut down for major upgrading or expansion. As well, there may be actual cash costs directly related to shutting down and re-starting production machinery that would be incurred during a retrofit. Our research revealed that virtually any retrofit involving a shutdown is likely to drive up costs significantly.

If a control system requires substantial electrical power, as is sometimes the case, the production facility's power plant may need upgrading. This would typically entail higher costs than would be incurred in meeting the same power requirements in a new facility.

The OAQPS manual suggests that site preparation costs may be lower for retrofits since most of this work will have been completed when the plant was built. However, our discussions with industry and consulting engineers did not find this to be a major cost issue.

All of the above issues relate to situations in which the control technology will be identical for new and retrofit applications. As noted above, new production facilities also tend to generate lower volumes of contaminants than older plants. As a result, substantially less spending for pollution control equipment may be necessary. This factor seems to be most important in wastewater control, because new plants tend to use far less water. This results in the need for smaller scale tanks, pipes and other equipment in the wastewater treatment system, and also generates wastewaters with higher concentrations, which may make treatment easier. Therefore, the capacity of a

treatment process installed in a new plant could be much lower, and much less costly, than that required for a retrofit.

This difference can also be present in air pollution control problems. A number of emissions now under review are linked closely to energy consumption. A new plant may have opportunities to build-in energy efficiency that are not available to an existing facility. Similarly, although solid waste management or disposal may entail comparable costs per tonne for a new or existing plant, the former can sometimes be designed to generate less waste material per unit of production.

3.3 Industry Discussions

Retrofit Costs Perspectives

This section largely draws on our discussions with industry representatives and consulting engineers. During these interviews, the costs of retrofitting specific pollution control technologies into existing production facilities were compared in a general fashion with the costs of installing that device (or meeting the same control standard) in a new or substantially redesigned production operation.

In some cases, firms had recent, practical retrofit experience, while cost discussions were more theoretical concerning the introduction of other technologies. Where possible, respondents provided "ballpark" estimates of incremental retrofit costs.

3.3.1 Non-Metallic Minerals [4]

Discussions with respondent consulting engineers and non-metallic minerals industry representatives suggests that higher costs tend to be incurred to retrofit air pollution control devices. It appears that additional retrofit costs may not be present for water pollution treatment, since most currently used pollution control techniques are placed outdoors, where space restrictions that boost costs are not frequently faced. However, as the industry address effluent concerns under MISA, retrofit costs may exceed the costs of meeting the same standards in a new facility, if the treatment equipment must be located inside operating plants.

One non-metallic minerals respondent cited a number of examples where their costs for air pollution control have exceeded the costs that a new plant would have incurred. These additional costs were incurred primarily because the existing layout of the plant was not optimally designed for the installation of the air pollution control

[4] This industry is alternatively referred to by the term "industrial minerals."

equipment, a situation that would be common for other industries installing similar equipment.

The firm installed an electrostatic precipitator (ESP) for the control of particulate emissions from its kilns. Some added duct work in retrofitting an ESP boosted the firm's costs by about 5% above what would have been incurred in a new facility. Similarly, extra costs of about 10-15% were incurred in a retrofit of several baghouses for the control of particulates and fugitive dust emissions in an existing plant. These added costs were a result of modifications of steel work needed for support of productive equipment, and holes that were cut in existing walls to vent out the cleaned air from the baghouses.

The firm's behaviour also indicates that it sought to avoid future retrofit costs. It installed baghouses that permitted them to achieve an air quality level well beyond existing environmental/health and safety requirements. Although this entailed higher current costs, the firm's actions demonstrate the it anticipates tighter standards in the future, and that it views the extra costs of meeting these standards today as being lower than the costs in the future of retrofitting existing equipment.

Higher retrofit costs are not universally present, however. One respondent cited a case in water treatment that did not entail higher costs than those that would have faced a new plant.

The respondent employed a CO_2 injection system in a settling pond for the control of the pH level in its wastewater. This system was retrofitted in an area outside the production facility with no added costs due to the retrofit. Originally, the firm pumped slurry water that contained precipitator dust out into a settling pond, but subsequently discovered that the pH of the water was too high. The pH adjustment system was added at the pumping point, which did not require any changes to the flow pattern of the waste water.

Therefore, no costs were incurred beyond what would have been necessary if the system had been installed as the production process was being constructed. We expect that this might be the case for other wastewater treatment systems that can make use of existing tanks, settling ponds, and other fluid handling equipment.

3.3.2 Industrial (Inorganic and Organic) Chemicals

As with non-metallic minerals control of dust, particulates and other air emissions at chemicals plants appears to entail higher costs for existing plants relative to new facilities. On the other hand, water treatment technologies may have only slightly higher retrofit costs, unless the production facility has a limited amount of surrounding land.

One consideration that may push retrofit costs above those incurred in a new or significantly redesigned facility is required water treatment capacity. In an existing operation, water usage is likely to be greater than in a new chemical plant. Thus, the capacity of a retrofitted treatment unit would need to be as larger, and more costly, than in a new chemical plant.

A retrofit of baghouse equipment for air pollution control would likely cost substantially more than the installation of a baghouse in a new production facility, according to engineers with inorganic chemicals firms. One respondent suggested that the retrofit costs could be anywhere from 25-50% higher.

Several factors contribute to this greater cost. In a new facility, a single larger baghouse could be installed to handle a number of sources, whereas retrofits tend to require a number of smaller units. Older furnaces are often not designed to accommodate such retrofits, and, therefore, structural changes to production equipment may be required. As well, the baghouse installation would require a shutdown of the operation which adds to the opportunity costs and actual cash costs of a retrofit. Finally, if a baghouse was being installed along with new production equipment, the baghouse would not have as much dust to deal with, and would be less costly as a result.

The installation of an incinerator for air pollution control is another example where retrofit costs are likely to exceed the installation costs in a new plant. This is due primarily to physical constraints within the production facility. The placement of a retrofitted incinerator is unlikely to be optimal. A brief shutdown of the operating plant may also be required. A 25% premium could be incurred during a retrofit, according to a respondent.

New production equipment is likely to have a scrubber built in. As a result, retrofitting scrubber equipment is believed to be more expensive. Older production units are not intended to have scrubbers fit onto them, requiring some redesign and shut down costs.

Inorganic chemicals respondents did not see water pollution control costs as being much higher for their existing plants than for new facilities. For example, the costs of constructing a sludge pond to control effluent contaminated with nitrogen on their site would not differ from building a sludge pond along with a new facility, unless the plant property has space constraints that prevent easy construction of a pond.

Another engineering respondent noted that for two technologies, commonly used in environmental protection in the organic chemicals industry, oil/water separators and biological treatment, the added

costs of a retrofit were likely to be only 5-10% above meeting the same regulations in a new plant. As long as the chemical facility has an adequate amount of land surrounding its buildings, adding a separator or biological reactor would entail extra costs except for in-plant piping connections. However, some disagreement was evident among our respondents as to whether Ontario plants generally have adequate space in which to easily retrofit water treatment processes.

3.3.3 Steel

Cost of installing environmental protection equipment in existing steel making facilities are thought to be higher than meeting the same standards in new or substantially redesigned facilities for both air and water pollution abatement.

In air pollution control, retrofit costs are thought likely to be between 20-50% higher than installing a scrubber system in a new facility. Ideally, a scrubber system should be close to the source of the metals contamination. In a retrofit, the scrubber is likely to be relatively far away from the point of contamination. As a result, a mix of air streams is likely to have to be fed into a retrofitted scrubber system. Handling such a mix of streams is less efficient than having individual scrubbers close to each source. Such individual units could be specifically designed to deal with the contamination in one particular air stream. The treatment system in a new plant would undoubtedly be laid out in this type of efficient pattern. Increased retrofit costs would also be caused by a need for greater ducting, added fan power, and extra structural supports than in a new facility.

Controlling particulates using a baghouse, or precipitator also entails a significantly higher cost in a retrofit than in a new steel mill. The costs of a retrofit are estimated by respondents to be 20-50% above the costs of installing baghouses in a new facility. The nature of the extra costs are similar to those for scrubbers – extra ducting and fans due to less efficient placement of the treatment device. As well, the productive process may need to be altered both to shift the flow of air and to accommodate ducting and/or treatment units.

Absolute filters are high-efficiency fabric filters designed to deal with small particulates (less than 10 microns). Retrofit costs are higher than installing new for several reasons. Since the filters are likely to be further from the source than optimal, extra ducting will be needed. As well, because the air stream must pass through a filter at a distance from the source, extra fan power is likely to be required. In order to ensure that this process works effectively, added electrical power may be needed in a retrofit, which could necessitate a new substation. The costs of increasing electrical power capacity would be greater when

retrofitting compared with installing the capacity all at once in a new process.

The control of polyaromatic hydrocarbons (PAHs) is a more recent area of activity in the steel industry. Since PAHs are only now beginning to be dealt with, few steel plants would have taken advantage of source reduction or process change measures to reduce emissions. A new plant or production process would use source reduction or process changes and would require less end-of-pipe capacity, whereas a retrofit would be more likely to rely on end-of-pipe control. In meeting the same control standard, a retrofit would be more costly as a result of this less than optimal control approach. Retrofitting scrubbers rather than controlling PAHs in a new plant or process is suggested to be much more costly – in the range of 20-50%.

The use of wet scrubbers for the control of sulphur dioxide raises many of the same issues as were evident for fabric filters. Retrofit costs may be 20-50% higher than new installation.

Another area of current and future concern will be the control of NOx, using a high efficiency, low NOx burner. Retrofit costs for low NOx burners are thought to be 20-25% above costs incurred when they are installed in a new or substantially redesigned production process. In a retrofit, the burner will generally not be in the optimal position as would be the case if installed in a new process. Shutdown costs would also be incurred in a burner retrofit. As well, an existing furnace may need some modifications to allow installation of new burners.

A catalytic oxidation unit is another approach to the control of NOx. It would ideally be integrated into the production process at the source of NOx. When retrofitting, the unit would be located outside the production process, which would increase ducting needs and reduce efficiency, thereby boosting costs by an estimated 20-50%.

Retrofit costs are also suggested to be 20-50% higher for catalytic incineration of VOCs. The reasons are similar to those for catalytic oxidation.

Changes in the combustion process are undertaken to control emissions of carbon monoxide (CO) in the steel industry. Usually, the design of the combustion process is altered, and monitoring equipment is installed. If a retrofit change of the combustion process is done, extra costs will be incurred in the shutdown of the productive process. As well, the final, retrofitted design may not be as efficient as the design of a new process that meets the same control standard. Added costs due to retrofit are suggested to be in the 20-50% range.

There are also substantial savings for new steel mills in water pollution control. One respondent noted that clarifier retrofit costs would likely be at least 50% above costs to meet the same standard in a new plant. This steel plant currently has a system that combines cooling, process, and storm water flows. These flows would have to be separated before clarifiers could be installed. In a new operation the water flows would be designed to be separate in the first place.

In a new steel plant, secondary treatment for suspended solids, dissolved solids, oil and grease would be done in one single treatment. Retrofitted processes would likely deal with contaminants one at a time. As well, a new plant would be more efficient in its use of water than existing steel mills. Therefore, a secondary treatment facility in a new plant would have to deal with smaller volumes of water than a retrofitted facility in an existing plant. These two factors are thought likely to cause retrofit costs to exceed installation in a new facility by 20-50%.

A retrofitted biological facility was likely to be installed in the near future at one steel operation. The costs of this retrofit were expected to be much higher than a similar process employed in a recently built steel mill. The main factor pushing up the retrofit cost in this instance is a lack of available space in which to easily accommodate a retrofitted biological process.

Added costs would be incurred in retrofitting a chemical treatment and settling system for heavy metals in a steel plant. Space considerations are likely to necessitate changes in the productive process or sub-optimal positioning of the treatment unit. In a retrofit, a larger volume of water would be treated, compared to the volumes that would be treated in a new, more water-efficient steel plant.

Water recycling systems are thought to be considerably more expensive to retrofit than to include in the construction of a new plant. One engineer suggested that retrofit costs could be three to five times higher. The steel production facility would have to be shut down line-by-line in order to rebuild, and perhaps separate, water flows. As well, most existing steel plants do not have much spare space in which to install water recycling equipment.

Hydrochloric acid used in steel production is often recycled. One firm noted that it has installed a recycling process in both a new mill and as a retrofit. The company found that the retrofit costs were roughly 10% higher, primarily due to a need to separate water flows in the existing steel operation.

Lastly, ammonia is frequently dealt with in vertical stills through a process commonly referred to as "steam stripping". Chemicals are introduced into the effluent to split ammonia into its constituent

nitrogen and hydrogen. These stills are evidently easier to fit in tight spaces than many other treatment devices. As a result, retrofit costs are thought to be less than 10% higher than meeting ammonia standards in a new facility.

3.3.4 Mining, Smelting, and Refining

Retrofit costs tend to be substantially greater than environmental control in new or substantially redesigned operations for air pollution control technologies. In contrast, little difference appears to exist for waste water treatment, except to the extent that new production facilities may be somewhat more efficient in their use of water, and require smaller effluent treatment capacity.

With regard to air pollution, one respondent is changing the process of copper production to yield higher strength SO_2 which in turn improves the productivity of acid plants. The retrofitted alternative would have been end-of-pipe scrubbers that produce gypsum sludge. The process change and retrofit scrubbers both have roughly the same capital costs, but the process change facilitates the production of saleable sulphuric acid. The gypsum sludge from scrubbers would have had no saleable value.

Wet scrubbers for particulate control were installed along with a new process by one respondent, at a cost that is believed to be much less than retrofitting on existing equipment. The retrofit would have been 2-3 times the cost of installing new because a significant reorganization of the production process would have been necessary.

Retrofits need not add higher costs in wastewater treatment applications in this industry. A calcium hydroxide addition and settling process for heavy metals involves changing pH to remove iron, then changing the pH again to precipitate other metals as hydroxides. This system was retrofitted by a respondent, who believes that there were no added costs as a result of the retrofit. The firm would have used the same technology if they had simultaneously been building a new production process, which suggests that in this case retrofit costs are comparable with the costs of installing in a new facility.

A centralized collection system for waste oil was retrofitted by one firm to reduce analysis costs. (The level of environmental contamination posed by the oil is often tested by the firm.) The retrofit cost was about 10% that which would have been incurred in a new operation due to duplication of engineering and purchasing efforts, as well as the need to fit the collection system around existing production equipment.

3.3.5 Petroleum Refining

Fewer added costs exist when retrofitting environmental protection processes in the petroleum refining sector, particularly for effluent treatment. Most of the productive equipment used in petroleum refining is located outdoors, and space-related retrofit problems are not as common as in many other industries.

If any additional costs would be incurred in retrofitting a sulphur plant as a part of SO_2/hydrogen sulphide control, they are thought to be well under 5% of the total costs to build a plant along with a new refining process. If a refinery was on a particularly small piece of land, space considerations might boost this percentage. The nature of the higher retrofit costs relate to the need for a slightly larger facility, since the firm could not take advantage of any source reductions available while building a new refinery.

Respondents differed on whether any additional retrofit costs exist in installing high efficiency burners for NOx control during a normal shutdown in an existing refinery relative to costs in a new refinery. Refineries are periodically shut down for routine maintenance, and it was believed by some that burners can be installed fairly inexpensively at such times. However, one engineering respondent noted that both the necessary lines to carry steam to the burner and NOx measuring devices would have to be fit, probably less than optimally, into an existing furnace in a retrofit. As well, the configuration of the furnace itself might need to be altered.

Some extra retrofit costs are believed to result when installing monitoring equipment that would ensure proper oxygen flows in order to minimize hydrocarbon emissions from burners. Sampling areas must be added by cutting a hole in an existing stack. The production facility would also have to be shut down to safely retrofit the monitoring equipment. The added retrofit costs are likely to be very site-specific, but may be at least 15% above new costs.

A "cyclone" centrifuge is often used to control particulate emissions. It is usually placed near the source of the particulates, and often comes with the process units. The retrofit costs associated with a cyclone centrifuge are judged to to be significantly higher than those incurred when installing the device in a new production process. In a retrofit of a centrifuge, major sections of the production process might have to be altered, and substantial extra ducting and piping would be required. As well, the emission stack for the air stream would likely have to be raised in order to meet ground-level concentration regulations for particulates.

Retrofit costs for biological treatment facilities in petroleum refining are thought to be 25-50% higher than expenditures required to meet

the same environmental standards in a new or significantly redesigned operation. A considerable amount of extra piping and re-routing of water flows would be needed in a retrofit, and alterations to the foundations of buildings might be required to re-construct the pipe works. Some constraints might also be faced when attaching the water system to the productive equipment.

3.3.6 Pulp and Paper

Pulp and paper mills generally face higher retrofit costs for air pollution control. However, discussions with industry participants and consulting engineers indicates that water pollution technologies may not necessitate greater retrofit expenditures, except to the extent that treatment capacity may need to be larger in a retrofit.

New pulp and paper mills have a number of technological alternatives for air pollution that cannot be utilized in retrofit applications, making environmental protection less costly when built-in to a new or substantially modified plant.

One respondent firm retrofitted a scrubber to control particulates. However, if they had been installing control technology in a new facility, the firm might well have used a different production process that would have reduced the flow of contaminants, and probably would have required a smaller scrubber. This difference in approach between new and retrofit is another example that a retrofit can involve a more costly approach than meeting the same control standard while building a new or redesigned facility.

Another respondent indicated that retrofit costs are likely to be higher for a baghouse to control particulates, and will increase with the age of the plant. However, the difference between retrofit and new costs for baghouses is thought to be less than with many other pollution control technologies in the pulp and paper industry because the technology involved is relatively less sophisticated.

Evidence exists that the retrofit costs of oxidizers used to control total reduced sulphur exceed the costs of meeting the same control standard in a new operation. According to respondents, oxidizers are generally not considered for this use in a new mill, which indicates that other, less expensive methods would be used to meet the same control standard in a new operation. An engineer noted that such units need to be close to the production process so that the gas does not have to be moved too far. The units are typically fairly large, and cannot be placed on unsupported roofs, so they must be put inside the plant. This placement would likely require significant alterations to the production process and/or the building.

Computer software for a plant's burning control systems can be used in NOx control. The same approach would be used in both a new and retrofitted mill, according to a respondent. Retrofit costs are not thought to exceed installation costs in a new mill since the technology is simply a software program to more precisely control burning.

Unlike many industries, retrofit costs for effluent treatment in the pulp and paper industry evidently do not greatly exceed costs of meeting the same standards in a new facility. Mills tend to be located near sources of pulp supply in areas where significant extra space is available. This permits fairly easy addition of retrofitted treatment processes. However, new mills can be designed to be more water-efficient, and thus a smaller capacity, less costly water treatment system can often be built along with a new mill.

Water pollution control can involve the same technology and systems in both new and existing mills. Unless space considerations are a problem, the costs of a clarifier, extended aeration basin, or activated sludge secondary treatment for BOD would not be higher in a retrofit than in a new plant, for a similar volume of water to be treated, according to a consulting engineer. Since anaerobic treatment uses less space than aerobic processes, retrofit costs are likely to be less for anaerobic systems.

In order to prevent shock flows into secondary treatment facilities, a spill collection and control system is quite likely to be retrofitted along with a secondary treatment facility. The retrofit costs for the spill system are likely to greatly exceed the costs of installing the system in a new plant, perhaps by as much as 50%. A retrofit of a spill control process would have to be fit into the existing plant, requiring extra pipe and involved installation procedures.

In order to develop a "closed-loop" approach to pollution prevention, water recirculation systems would have to be installed in pulp mills. The costs of retrofitting such a recirculation system into an existing plant are thought to be at least 50-60% greater than the costs of installing a system in a new pulp mill. Some of the production equipment would need to be replaced to recirculate water. As well, in a retrofit, pipes, pumps, and tanks would not be able to be placed in optimal positions because of the production equipment already installed.

In the next several years, one respondent firm plans to retrofit a chemical treatment system for wastewater for a pulp and paper mill. The need to build greater treatment capacity than would be necessary if a new water-efficient production facility was also being built will likely push the retrofit costs above the costs of meeting the same control standards in a new production facility.

A retrofitted collection system for chemicals found in mill wastewater is estimated to have cost about 50-60% more than would have been necessary to meet the same control standard in a new facility.

3.3.7 Vehicle Assembly and Parts

According to our respondents, retrofit costs for wastewater treatment in vehicle assembly were unlikely to be much greater than costs of installation in a new plant, as long as adequate space was available outside the buildings.

Most vehicle assembly operations have separate wastewater treatment plants, which are typically some distance from the production area. In a retrofit, some minor added costs might be incurred because assembly plant floors would have to have trenches dug into them to move the water to the treatment plant. However, since all Ontario auto plants have existing treatment operations, this cost would not be incurred because a retrofit of a treatment plant would not be necessary.

A common process in assembly plants involves dipping metal body parts in cleaning solution before paint is applied. This procedure develops alkalinity and phosphorus contamination in wastewater, which are normally dealt with by pH adjustment and precipitation in settling tanks. Retrofit costs were believed to be only slightly higher, perhaps 5%, than costs in meeting similar standards in a new plant. The retrofitted treatment process can be installed at some distance from the cleaning process and fitted relatively easily into treatment facilities.

Other common treatment process include pH control and precipitation of heavy metals resulting from metal finishing processes. Retrofit costs tend to be very similar to cost in new operations because control systems can be at some distance from the production operations where space is not a major concern.

More typically, a new treatment process would have to be installed in an existing wastewater treatment plant itself. However, the retrofit costs of the following additional treatment processes are not believed to be much greater than installing the process when building a new treatment plant: oil-water separators for free oil; chemical, thermal, and membrane treatments for emulsified oil (in solution); and, paint–solid-liquid (API) separators.

Metal Casting

Respondents familiar with metal casting processes, whether in auto parts manufacturing or other metal casting, generally felt that higher costs were incurred in retrofitting relative to installation in new plants.

Particulates are the only major air concern for casting operations. Retrofit costs for scrubbers, baghouses, or precipitators were thought to be only moderately higher, perhaps 10-15%, than in a new facility, due to extra ducting and fan power needs.

Water treatment is the main environmental protection issue for casting firms. Costs were generally viewed as being considerably higher to retrofit treatment processes rather than addressing the same regulations in a new or redesigned production operation.

Retrofit costs of adding a lime hydroxide precipitation process for the control of metal fluorides to the existing stock of wastewater handling process are thought to be above those to install in a new treatment process. However, an industry respondent was not able to estimate the extent of these cost differences. This firm would likely have used a different approach if building a new treatment facility. A new facility would either treat several problems (including metals/fluorides) together, or use a clarifier, which would settle chrome sludges. The fact that a different technical approach would be selected in a new plant suggests that such an approach is in fact more cost-efficient than the approach used in a retrofit, where there are constraints in the choice of technologies as a result of the existing equipment in place.

A retrofit of carbon filters to control phenols is planned in the near future at one respondent operation. Duplication of design and construction costs will result because the treatment building will have to be expanded to house the new filters, although no percentage estimate for added costs was obtainable.

In contrast, retrofit costs are not anticipated to exceed the cost of new during a planned addition of an aeration process for the control of organics (BOD) at one metal casting facility. The treatment process is a series of several small (45 gallon) tanks with air injection devices. The production facility has space in which to place the relatively small amount of equipment, and only very minor piping changes will be required.

Filter presses are used to reduce the volume of chrome sludges produced by de-watering. Retrofit costs are thought to be at least 10% above the cost of new as a result of structural modifications to accommodate the filter presses, and a requirement to alter the position of other treatment processes.

Foundry sand presents a solid waste management issue to metal casting operations. Chemically-bonded or clay-bonded sand is used as molding medium, often to form the hollow sections of cast metal. Thermal recycling systems are sometimes employed by firms to clean sand for re-use. Retrofit costs were suggested to be only marginally higher, perhaps 5%, than the costs of installing such a system in a

new facility. However, all respondents noted that their operations had available space. Foundries with space constraints would likely see higher retrofit costs.

Metal Plating

Retrofit costs are generally higher in metal finishing facilities, because plants are often older and cramped. Retrofits would normally require significant and costly reconstruction of buildings and production processes. However, this tends to apply more particularly to independent shops, rather than new automotive assembly operations that may have more internal plant space to work with. One consulting engineer who works primarily with small to medium-sized plating shops indicated that retrofits of waste treatment processes are hardly ever done, due to prohibitive costs when compared with meeting environmental standards in new operations.

Retrofit costs for chemical precipitation of metals from wastewaters are thought to be twice those faced in new metal plating plants. The treatment process involves changing the pH of the wastewater, causing the metals to settle into a sludge, which is subsequently de-watered. Ideally, the precipitation of various metals is segregated and is done close to the source. In a retrofit, such segregation of treatment facilities may not be possible due to space considerations. Retrofitted treatment processes are likely to be further from sources, require more piping, and be less efficient than similar processes installed in a new production process or plant.

Electro-oxidation is used to deal with solutions with high amounts of metals, and can be the first stage of a treatment process. As with chemical precipitation, the costs of retrofit are believed to be substantially greater than installing electro-oxidation equipment in a new facility, for similar reasons. Similarly membrane filtration, used as a step in metals treatment during or after chemical treatment, entails significantly higher costs in a retrofit application.

Vacuum evaporation uses electricity to evaporate the wastewater, leaving a metal slurry. In retrofitting such a treatment process, the wastewater flows may need to be separated. This separation involves changes in existing water flows, and a respondent estimated this step to add 20-30% over the costs of installing a vacuum evaporation process in a new production facility

3.4 Conclusions

Our interviews with in-house and consulting engineers suggest that higher costs for retrofit as opposed to new plant applications of environmental technologies are quite pervasive. These environmental

retrofit costs range from only 5-10% above new plant application costs to 50-60%, or more.

The cost increases are more likely to be present in indoor applications where space limitations create sub-optimal layouts in retrofits. They are also more prevalent in cases where the best available technology entails a process change solution as opposed to an end-of-pipe approach, or where process change can reduce the flows of wastes to be treated.

Where these factors are not present, there are fewer advantages to industries in timing environmental protection requirements to be coincident with major non-environmental capital improvements or expansions. This may be the case, for example, in some measures taken to reduce NOx emissions (e.g. some conversions to low NOx burners) or in additions to existing external wastewater treatment plants.

Table 2 summarizes the findings with regard to new versus retrofit costs by industry. These cost figures are based on top-of-mind estimates of industry representatives and consulting engineers, not detailed cost studies.

Table 2 – Summary of Retrofit Cost Estimates

Industry	Interviews	Extra Cost for Retrofit (air)	Extra Cost for Retrofit (water)
Industrial Chemicals	6 - industry 4 - engineers	25-50%	0-10%
Metal Casting[5]	5 - industry	10-15%	0-10%
Metal Plating	2 - industry 3 - engineers		20-100%
Mining/Smelting/Refining	4 - industry 2 - engineers	200-300%	0-10%
Non-Metallic Minerals	5 - industry 1 - engineer	5-15%	none
Petroleum Refining	3 - industry 3 - engineers	0-15%	25-50%
Pulp & Paper	4 - industry 5 - engineers	higher, but no percentages given	0-60%
Steel	5 - industry 2 - engineers	25-50%	5-50%
Vehicle Assembly and Parts	2 - industry 2 - engineers		0-5%

5 Systems to re-use foundry sand are being employed in in Ontario. Respondents suggested that retrofit costs might be less than 5% above the cost in a new facility. However, firms with binding space constraints may face higher retrofit costs.

4. Financial Considerations in the Timing of Environmental Investments

4.1 Introduction

As we noted in Section 1, the existence of cost savings in installing environmental protection equipment in new or substantially modified plants suggests that regulatory changes be timed to match industry investment cycles where possible. Financial considerations could in some ways add to the incentive to do so, but in other ways might reduce the benefits of timing environmental changes in this way.

As noted in Section 1, there are two primary financing considerations in timing of environmental spending requirements.

1. Internal sources of capital (i.e. retained earnings) are generally less costly than external capital. This suggest that there are advantages to having environmental protection capital spending coincide with a period in which earnings are high relative to the firm's other investment capital needs. These boom periods will also often, but not always, coincide with periods of high investment in new plant and equipment.
2. Where external sources of capital are used, the incremental borrowing for environmental spending could mean that the firm would face higher capital costs in periods in which it is already borrowing heavily or issuing large volumes of new shares. This in itself might suggest that environmental spending should not coincide with high periods of non-environmental capital spending. However, external equity or debt issues might be priced more favourably (i.e. require a lower yield to be paid to buyers) when the company is in a strong financial position, which is more likely to coincide with a boom period and higher capital spending.

To clarify how these sometimes competing forces affect Ontario businesses in practice, we raised these issues with nine senior finance executives from the industries covered by this study. A group of this size cannot yield statistically significant results, but does give an indication of the views of executives involved with the financing of environmental protection projects. As well, the officers interviewed are employed by some of the largest firms in the province, and are responsible for a disproportionately large share of environmental spending in Ontario.

4.2 Findings

From a cost of financing point of view, companies preferred to meet new environmental regulations during periods of significant upgrading of productive facilities, rather than during lulls in capital spending. Higher financing costs for productive plant and equipment caused by simultaneous environmental requirements do not seem to have been a major factor for the firms surveyed.

The cost of financing issue was clearly distinct from the fact that the *total* amount of financing needed by firms may have been greater if they were to meet environmental regulations while staying competitive. Any increase in total financing requirements caused by environmental rules was a very important consideration for all firms surveyed. However, since financing costs have evidently not been pushed up for the companies surveyed, it appears that finance officers have tried to maintain target debt-equity ratios, and have cut spending on productive capital investments in order to meet environmental needs.

Two executives did believe that the costs of financing productive capital purchases had been pushed up by the need to make environmental investments at the same time. However, these officers generally maintained that lower costs of installing environmental protection technologies in new or redesigned facilities outweighed any financing cost penalties.

The movement toward source reduction, rather than end-of-pipe control, has affected the views of finance executives.[6] Finance officers understand that newer, more stringent, environmental limits can often only be met through production process changes. As a result, the cost of financing issue may play virtually no role in a firm's environmental investment decision. If a firm intends to remain in business in a jurisdiction, a firm must meet its control orders. Since achieving the required level of control may only be possible through source reduction, environmental investment is undertaken at the same time as production processes are being installed or substantially upgraded.

The perceived viability of a productive facility or line of business has a strong effect on the decision to invest in environmental protection equipment. One pulp and paper finance executive noted that no firm would invest in environmental protection equipment unless the mill in question was believed to have a future. Of course, productive

6 In our work for this project and others for the Ministry, this technological trend has been evident in a number of industries. As pollution control gains from end-of-pipe devices are exhausted, "pollution prevention" efforts begin to take precedence.

investment is also only undertaken if a given mill is seen to have a favourable business outlook. Since the decision to spend significant amounts on productive capital is often the point at which the long-term future of a plant is most clearly considered, firms may feel most comfortable with making environmental expenditures as they substantially upgrade their operations.

In addition, three or four finance officers suggested that firms may often not be willing or able to finance environmental protection projects during troughs in their industry's investment cycle. In many manufacturing industries, capital investment is affected by the business cycle of the entire economy. Firms in these industries will undertake investment projects in periods when profits are high, usually during economic expansions. Less capital spending will occur during recessions, when profits are often low or non-existent. Thus, firms may not have adequate internal cash flow to finance environmental protection projects during slowdowns in industry investment. Such companies would not be in a position to consider a shift of environmental protection investments away from the peak of the industry investment cycle.

On a related point, an environmental manager for a steel operation mentioned a "psychological" problem with retrofitting environmental protection technology. Environmental costs are considered when a new or redesigned facility is being designed. This individual also noted that construction of a such a new or upgraded productive facility would only go ahead if the firm believed that an appropriate payback (including environmental costs) would be forthcoming. In the case of a retrofit, particularly of end-of-pipe equipment, firms do not generally believe that any payback will be likely. Meeting environmental standards in new operations gains further favour relative to retrofitting because the improved profit performance of a new facility can help to defray environmental protection costs.

Thus, on balance, we conclude that financing issues tend to reinforce, rather than oppose, the incentives created by cost considerations for timing environmental requirements to coincide with major periods of industry investment.

5. Understanding and Anticipating Investment Cycles in Ontario Industries

5.1 Introduction

The results presented in the previous sections suggest that the Ministry of the Environment should, where possible, time its environmental regulatory requirements to coincide with major capital expansions or upgrading by the industry subject to the regulation. This will in some cases mean that the Ministry will have to speed the development of new standards in order that they be communicated to an industry as new or modified plants are in the design stages. In other cases, where the contamination is not an immediate health threat, it could mean allowing a year or two delay in meeting a standard if this will enable the measures to be taken in conjunction with an upturn in the industry's capital spending.

Because of the many factors that influence capital spending decisions in complex ways, forecasting the path of future investment spending in any given industry is very difficult. A variety of projection approaches are available, such as industry intentions surveys, econometric models, statistical analyses, and judgmental analysis. To date, none of these methods, either individually or in combination, has proved very successful. Investment spending projections remain among the most unreliable of economists' forecasts.

As part of our work in this study, we have assembled data on capital spending and some of its key explanatory factors for the industries under consideration. Our analysis of the past behaviour of capital spending by industry confirms that distinct investment cycles characterize industry spending for all the industries covered. In some cases, investment spending patterns appears to bear only a small relation to trends in capital formation in the rest of the economy, but rather reflect the dominance of various industry-specific considerations. In others, industry investment cycles match fairly closely the investment cycle for the rest of the economy. Where significant similarities have existed in the past, the Ministry will be able to base its assessment of that industry's investment on the outlook for overall capital spending.

Where no such similarities are evident, investment spending projections for individual industries will require especially careful attention to industry-specific conditions, including the prospects for product prices, industry profitability, and capacity utilization. Considerable past research confirms that no simple, reliable relationship exists between investment spending and any one of these

factors. It will be necessary to incorporate an array of explanatory factors in any assessment of future capital spending projections.

The Ministry should bear in mind that accurate forecasts of the future *level* of industry investment are both unlikely in practice (for the reasons already given), and unnecessary in determining the point at which new regulations should be issued by the Ministry. What is of paramount importance in this application is to obtain a reasonable sense for the timing of forthcoming *bursts* of investment spending in the industries of interest, rather than precision on the strength of these bursts. Once this is ascertained, the Ministry will be in a better position to formulate its plans for the introduction of new environmental protection requirements in harmony with industry developments, where this is the preferred approach.

5.2 Investment Spending Analysis

Methodology

In this section, we turn to a brief consideration of the practical ways in which the Ministry could attempt to understand and anticipate capital cycles in some of the key industries it regulates. The recent investment spending patterns in these industries are reviewed.[7] Then, a set of recommendations for monitoring and assessing trends in capital cycles are developed.

It is well-known that investment spending for any given industry is influenced by a wide array of considerations. Many of these relate to the expectations of business concerning future market demand and supply conditions, product prices, and profitability. Investor attitudes are of special importance. Technological advances may play a key role, as changes may render existing capacity obsolete. For many products traded internationally, investment decisions reflect conditions in competing jurisdictions. Broad macro-economic considerations, including exchange rates, inflation, and financing costs also play an important part in the investment decision-making process. Finally, particular factors such as requirements to reduce or eliminate negative environmental impacts may also spur new capital spending.

For each industry, investment spending is a reflection of many of the above factors at different times. Thus, it is not reasonable to expect that a simple approach to explaining past capital formation or future expenditures will be common to the industries under consideration. However, for all industries, the broad underlying macro-economic influences will be the same, and investor attitudes and market

---

7 Capital investment data presented in this report are for the entire Canadian industry. Detailed industry figures are not available at the provincial level.

conditions are often highly correlated across industries during business cycles. For this reason, we first investigate the extent to which the variation of the capital spending of each industry is similar to fluctuations in investment in the rest of the economy. If the cycle in an individual industry largely tracks investment in the economy as a whole, then the Ministry will be able to use widely available forecasts and commentaries on aggregate investment spending to anticipate the likely trends in the particular sector under consideration.

Investment spending is highly volatile and often "lumpy". However, over a medium term time horizon there is usually an underlying growth trend about which spending oscillates. If deviations both above and below this trend are substantial, then industry spending displays cyclical performance. If the pattern of deviations from trend for an individual industry is similar to that for the rest of the economy, then the industry and economy-wide investment cycles are similar.

Our analysis has been designed to examine the variability of investment spending by industry about this underlying trend, and compare this to the rest of the economy. For this purpose, we collected annual data on investment spending by industry in constant 1986 dollars over the last thirty years, which includes at least three complete business cycles. (While quarterly data would have been more useful in investment cycle analysis, disaggregated industry data is not sufficiently available on a quarterly basis.)

Subsequently, we manipulated the investment spending data by:

1) plotting the trend line of the logs of the series;

2) calculating the deviation of the actual log values from the log values along the estimated trend line;

3) standardizing these deviations by dividing each by the statistical standard deviation of the respective series; and,

4) calculating a simple regression coefficient (and the associated t-statistic) obtained by regressing the standardized deviations for a given industry against the corresponding standardized deviations for investment spending in the rest of the economy.

This procedure allows both statistical and visual examination. As a result of the standardization of the deviations, the regression coefficient is equivalent to the correlation coefficient between the two series of deviations. A statistically significant, positive coefficient indicates some degree of co-movement of the two series around their respective growth trends. A coefficient that is not significantly

different from zero suggests that any observed linkages between the two series are not sufficient to confirm the existence of a link.[8] In addition, when the standardized deviations from trend of a given industry and the economy as a whole are plotted on a graph, one can visually inspect whether the two investment series appear to be cyclical, and whether the cycles seem to be related.

Where we identify an industry with investment patterns that have not closely tracked those of the rest of the economy, we have undertaken further work to identify some of the factors whose behaviour may have accounted for investment spending differences in that industry. As part of this work, the study team spoke with analysts with banks, firms, and industry associations to identify considerations that might be relevant to the capital spending patterns of each of these industries.

We have not developed any formal investment models, since we are not particularly concerned with establishing causal links between these factors and investment spending. Rather, this study provides evidence that the change in factors suggested by industry observers tend to precede, or are correlated with, industry investment swings.

The major factors affecting investment identified through these interviews and study team analysis are:[9]

- **the economy-wide business cycle**;

- **industry profits**;

- **capacity utilization**;

- **prices received by firms for their outputs**;

- **real interest rates on long-term corporate bonds**. A significant problem with analyzing the impact of real interest rates is that it is the *expected* real rate, as opposed to the realized rate, that is likely to matter for corporate investment. As a result, we have not attempted to uncover real interest rate effects on investment in the industries under consideration. However, the Ministry may wish to monitor industry expectations of real long-term interest rates; and,

- **technological progress**. Often, investment surges are generated in a particular industry by advances in process or product technology.

Individual industries will often have industry-specific influences on capital spending such as technological advances and changes in

---

8 The critical t-statistic for significance in our analysis is 2.045.

9 Sources for these and other industry-specific indicators are included in the appendix.

customer demand. Sources of such information are noted in the discussion of industries that have shown investment performance substantially different from the economy as a whole.

5.2.1 Non-Metallic Minerals

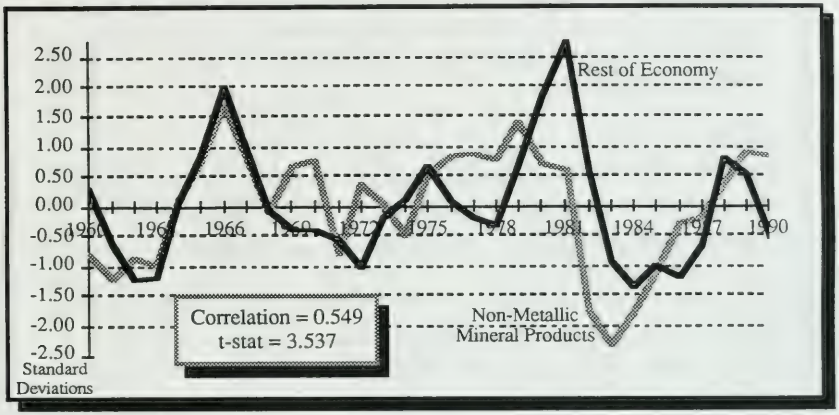
The non-metallic minerals industry has displayed a fairly distinct cyclical investment pattern, except perhaps during the 1969 to 1975 period (see Chart 1). A moderate degree of volatility about the long-run trend is also evident in the capital spending history of the industry. The mid-1960s, late 1970s, and late 1980s saw particularly strong peaks. Spending was relatively depressed in the early 1960s, and fell dramatically during and after the 1981-1982 recession.

Analysis of deviations from trend shows a fairly strong degree of co-movement between industrial minerals investment and that in the rest of the economy. In fact, a strong relationship is indicated by the data.[10] This analysis suggests that this industry is affected significantly by economy-wide factors when investment decisions are made, and appears to have less of an industry-specific investment cycle.

[10] A correlation of 0.549 exists between the standardized deviations from trend of the industry and the rest of the economy, and was significant with a t-statistic of 3.537, which was the closest for all the industries studied

Chart 1

Standardized Deviations of Log of Investment from Trend (Non-Metallic Mineral Products and the Rest of the Economy)



Source: Ernst & Young calculations.

Construction firms are major users of non-metallic mineral products, and many of the surges in investment by the non-metallic minerals industry can be attributed to growth in construction activity that takes place during economic expansions. For instance, the strong recovery in investment seen in the mid- and late 1980s can be largely attributed to the boom in construction experienced in southern Ontario during the 1980s.

Generally, tracking the movement of output and investment for the economy as a whole, and monitoring widely available forecasts for total business investment spending, are likely be quite helpful in anticipating movements in the capital spending pattern of this industry. Since non-metallic mineral products are frequently sold to the construction industry, indicators of construction activity such as building permits for commercial and industrial projects should be monitored. However, this business is very regional in nature due to substantial transportation costs. Therefore, the Ministry should concentrate on monitoring economic and construction activity in Ontario, and perhaps Quebec, when reviewing prospects for non-metallic mineral investment in the province.

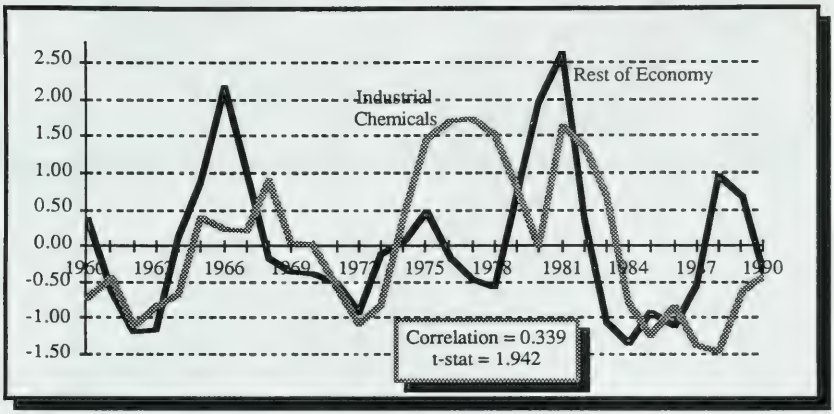
5.2.2 Industrial (Organic and Inorganic) Chemicals

Investment in the industrial chemicals industry has demonstrated a cyclical pattern that has not always matched the investment pattern of the rest of the economy (see Chart 2, which combines investment in

both the inorganic and organic chemicals industries)[11] Most notably, the relative strength of industry capital spending in the mid to late 1970s and the relative weakness in the latter part of the 1980s were deviations from trend not matching those elsewhere in the economy. The movement above trend in the late 1970s and early 1980s reflects the strong investment in petrochemicals in Alberta, as the industry experienced structural shifts away from Ontario in order to be closer to sources of supply.

Chart 2

Standardized Deviations of Log of Investment from Trend (Industrial Chemicals and the Rest of the Economy)



Source: Ernst & Young calculations.

Industry-Specific Factors Affecting Investment

During the last twenty years, total profits among industrial chemicals firms have given some indication of the future investment pattern of the industry (see Chart 3). The bulge in the late 1970s due to the development of an Alberta-based industry is not explained by profitability. Otherwise, the pattern of lagged profit[12] bears a resemblance to investment in following years.

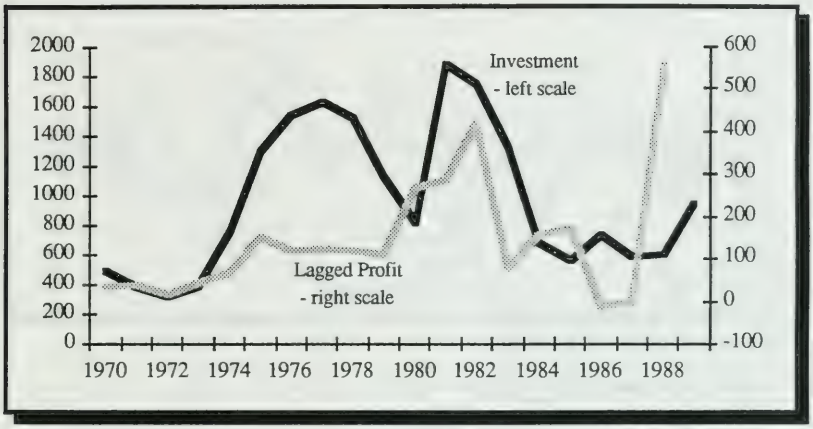
---

11 A correlation coefficient of 0.339, although not quite significant at the 95% level, does seem to indicate that industrial chemicals investment often matches the fluctuations from trend occurring in the rest of the economy.

12 The term "lagged profit" means profits earned in a prior year. Since investment spending decisions are often made well ahead of actual expenditures, profits earned in prior years will likely have a strong impact on current capital investment spending.

Chart 3

Investment and Profits in the Industrial Chemical Industry[13] (Millions of 1986 Dollars)



Source: Statistics Canada, Investment and Capital Stock Division; and, Statistics Canada, *Industry Financial Statements*, 61-207.

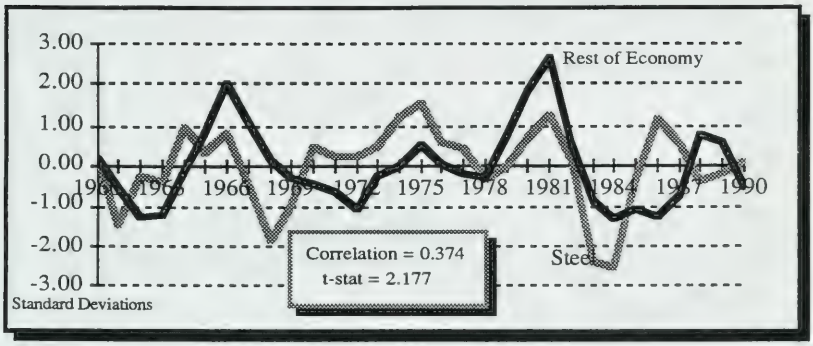
5.2.3 Steel

Annual capital spending in the steel industry has shown a discernible cyclical pattern since 1960, during which time capital spending has varied moderately around its long-run trend (see Chart 4). As expected, these fluctuations in industry investment appear to be somewhat related to movements in capital spending in the rest of the Canadian economy.[14] Peaks in steel industry spending in the mid 1960s, mid 1970s, and early 1980s were concurrent with strong investment performance elsewhere in the economy. Only with the rapid recovery of steel investment in the mid 1980s and the subsequent slackening in the later part of the decade does the industry appear to have differed sharply from the rest of the economy in its variation from the long-run trend in capital purchases.

[13] In this chart, profit data have been lagged by one year. In other words, the figure for 1980 represents profits earned in 1979.

[14] Analysis of the correlation between the deviations from trend shows a significant coefficient of 0.374, with a t-value of 2.177.

Chart 4
Standardized Deviations of Log of Investment from Trend (Steel and the Rest of the Economy)

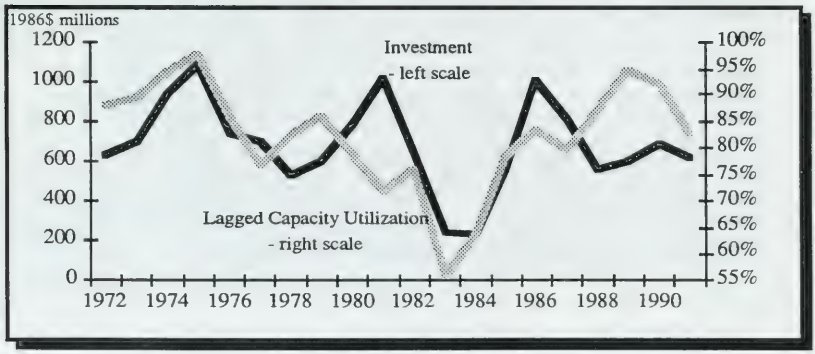


Source: Ernst & Young calculations.

Industry-Specific Factors Affecting Investment

The level of capacity utilization appears to lead steel investment, but the lead period has varied over the last twenty years (see Chart 5). Investment decisions are often made well ahead of actual capital spending. Thus, capacity constraints experienced in prior years will have an impact on current capital spending.

Chart 5
Investment and Capacity Utilization in the Steel Industry[15]

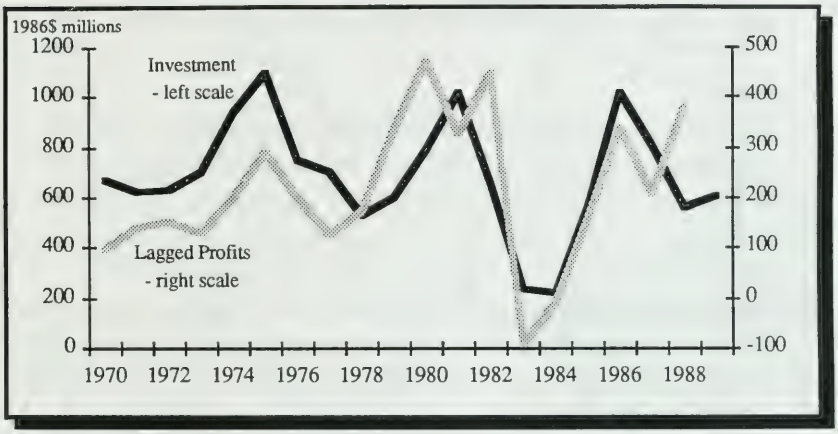


Source: Statistics Canada, Investment and Capital Stock Division.

[15] Capacity data is for primary metals, of which steel accounts for 70% of activity. Capacity utilization figures here have been lagged by one year. In other words, the value applicable to 1980 in the chart was capacity usage that prevailed in 1979.

Since a sizable proportion of investment is financed out of internally-generated funds, and because profitability is also linked to capacity utilization in this capital-intensive industry, it is not surprising that corporate profits in the steel business also appear to lead changes in investment (see Chart 6).

Chart 6
Investment and Profits in the Steel Industry[16]



Source: Statistics Canada, Investment and Capital Stock Division; and, Statistics Canada, *Industry Financial Statements*, 61-207.

Activity in the North American automotive industry is quite important to Ontario steel firms. Two of the largest users of steel are the vehicle assembly and auto parts industries. The Ministry may wish to monitor activity in the auto sector in order to gain insight into investment potential in the steel business. As well, the consumer durables sector has tended to be an important purchaser of Ontario-made steel. An awareness of activity in this sector may be worthwhile when considering the future of steel investment.

5.2.4 Metal Mining, Smelting, and Refining

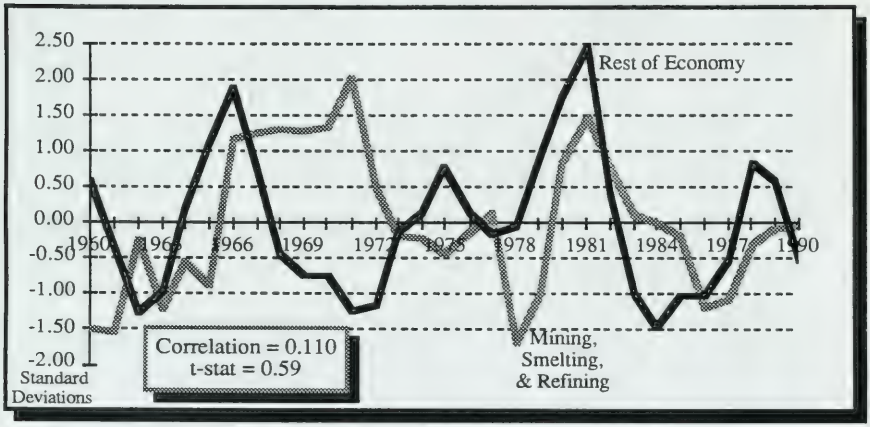
Investment in metal mining is characterized by noticeable volatility, and has shown signs of a cyclical pattern that does not match the investment pattern of the rest of the Canadian economy (see Chart

[16] The profit data in this chart have been lagged by one year. In other words, the value applicable to 1980 in the chart represents profits earned by steel firms in 1979.

7).[17] Two particular periods are noticeable – strong industry spending during 1966-1972 while other investment was weak, and a sharp downturn in the late 1970s at the same time as investment in the rest of the economy was growing strongly. Industry-specific factors are evidently more important in determining mining investment than the general business cycle in Canada. This fact is not surprising since Canadian mining firms have long operated in a global, not a national, market. As a result, the Ministry may wish to monitor global economic activity, rather than just looking at Canada's economic performance, when considering mining, smelting, and refining investment.

Chart 7

Standardized Deviations of Log of Investment from Trend (Mining, Smelting, and Refining and Rest of Economy)



Source: Ernst & Young calculations.

Industry-Specific Factors Affecting Investment

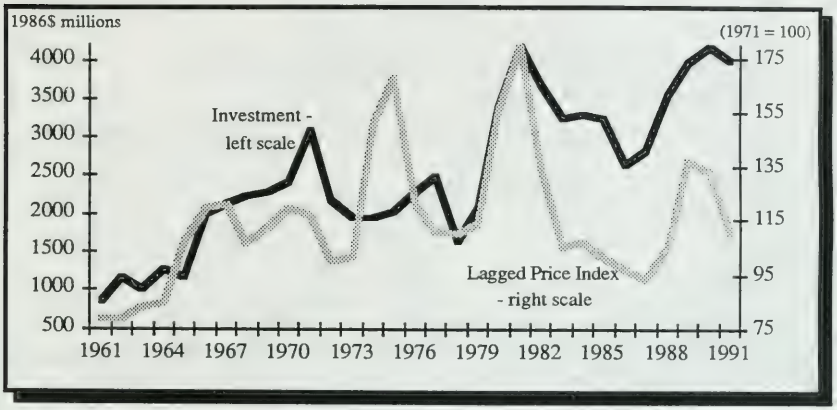
As metals prices rise, the return to investment tends to rise and greater capital spending is often undertaken, according to industry analysts (see chart 8). Visual inspection of data indicates that the behaviour of

[17] No significant correlation exists between the standardized errors from trend of the logs of mining investment and investment in the rest of the economy, as shown by a coefficient of 0.11 with a t-statistic of 0.59.

a weighted index of real metal prices[18] often leads investment in the mining, smelting, and refining industry.

Chart 8

Mining/Smelting/Refining Investment and Metal Prices[19]



Sources: Statistics Canada, Investment and Capital Stock Division; and, Energy Mines and Resources Canada, Mineral Policy Sector.

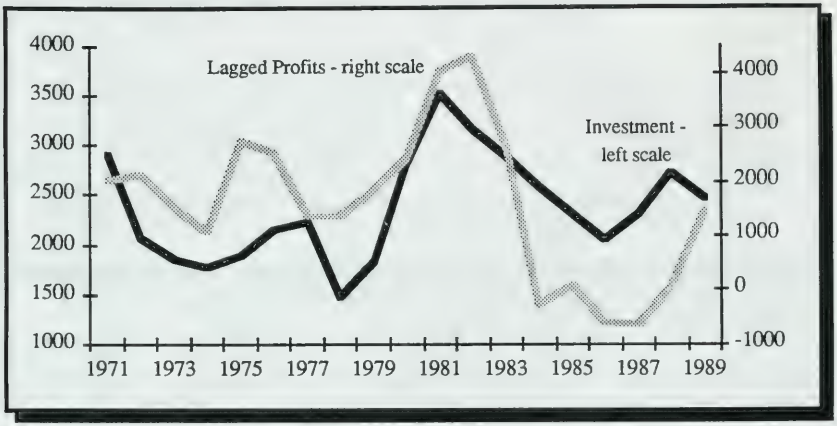
18 The "Canadian Real Metals Price Index" is weighted according to Canadian production of six key metals, and is deflated by the GDP implicit price index for Canada. Source: Energy, Mines and Resources Canada, Mineral Policy Sector.

19 Note that the real metals price index figures in this chart have been lagged by one year. In other words, the value applicable to 1980 in the chart was the value of the index that prevailed in 1979.

Mining industry profits are an important source of funds to finance capital investment. The significant moves in investment in the industry appear to be presaged by sizable shifts in industry profitability (see Chart 9). As with the metals price index, lagged profits display a similar pattern to industry investment.

Chart 9

Mining/Smelting/Refining Investment and Profits (Millions of 1986 Dollars)

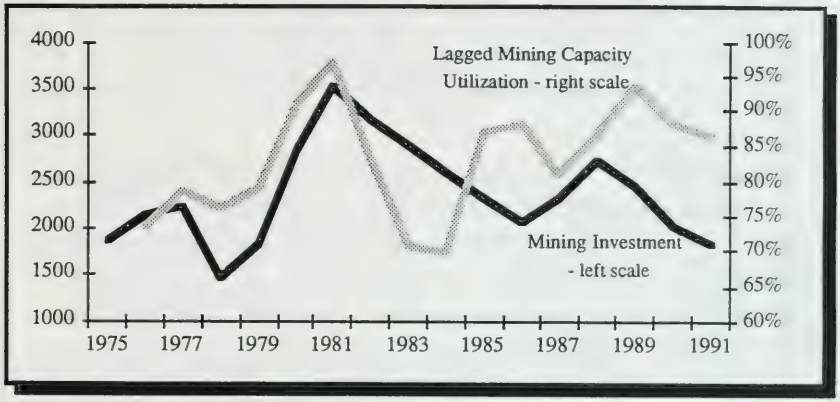


Sources: Statistics Canada, Investment and Capital Stock Division; and, Statistics Canada, *Industry Financial Statements*, 61-207.

Availability of capacity may also play a role in determining investment in mining, smelting, and refining. The pattern of capacity utilization in the mining industry bears a strong resemblance to the movement of capital spending over the period of 1976-1991 (see Chart 10).

Chart 10

Investment and Capacity Utilization in Mining, Smelting, and Refining[20]



Sources: Statistics Canada, Investment and Capital Stock Division, and Energy, Mines and Resources Canada, Mineral Policy Sector.

The mining industry is quite diverse, and maintaining an awareness of investment prospects would necessitate monitoring developments in several industry segments. In Ontario, the most significant production and processing involves nickel, gold, copper, zinc, uranium, and silver. Since mining is a global industry, new finds anywhere in the world can have an effect on investment at Ontario mining, smelting, and refining operations. As a result, the Ministry may wish to monitor important new deposit discoveries of these minerals, wherever they are found.

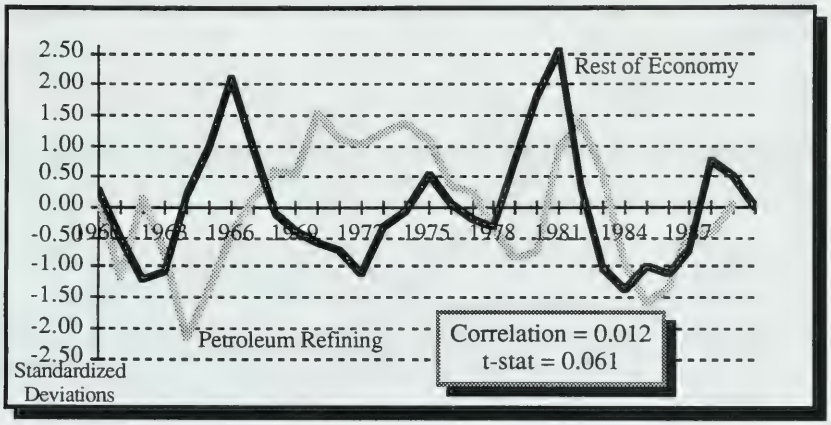
[20] The data in this chart is for mining only, since capacity data for smelting and refining are included as an inextricable part of the primary metals sector. Note that the capacity utilization figures in this chart have been lagged by one year. In other words, the value applicable to 1980 in the chart was the value of the index that prevailed in 1979.

5.2.5 Petroleum Refining

Capital spending in petroleum refining in Canada has not closely matched the investment pattern of the rest of the economy, although this industry has displayed a clear cyclical investment pattern (see Chart 11). Over the last three decades, the deviations from trend of capital spending in the refining industry appear to be almost completely unrelated to capital spending in the rest of the economy.[21]

Chart 11

Standardized Deviations of Log of Investment from Trend (Petroleum Refining and the Rest of the Economy)



Source: Ernst & Young calculations.

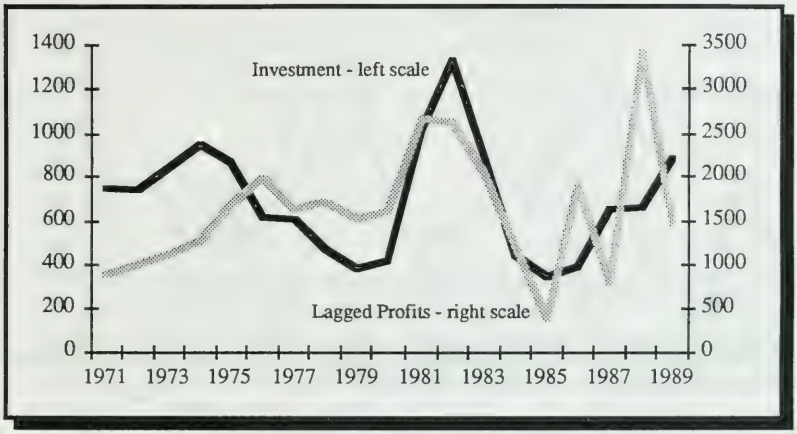
Industry-Specific Factors Affecting Investment

The level of investment seems somewhat related to petroleum refining profits in the previous couple of years (see Chart 12). Visual inspection shows that a stronger connection appears to have developed since the late 1970's. Prices received by refiners were also mentioned by analysts as having some effect on industry investment, particularly the prices for motor gasoline and fuel oil. Price increases often influence expectations of future profits.

[21] The correlation coefficient of 0.012 between the standardized deviations from trend of the two series is not significantly different from zero with a t-statistic of 0.061.

Chart 12

Investment and Profits in the Petroleum Refining Industry [22] (Millions of 1986 Dollars)



Sources: Statistics Canada, Investment and Capital Stock Division, and Statistics Canada, *Industry Financial Statements*, 61-207.

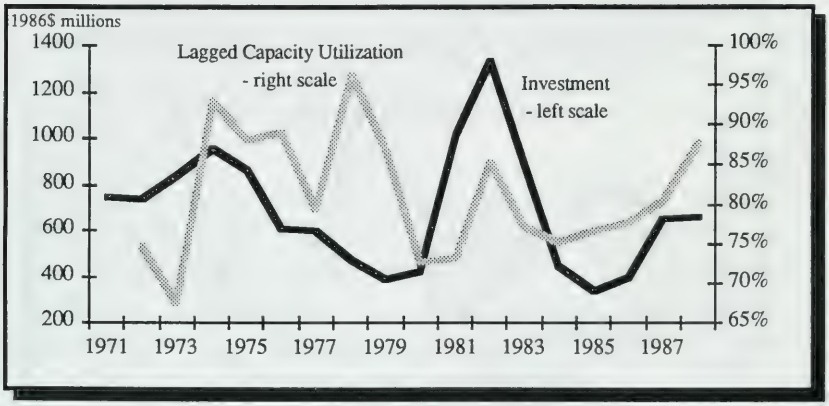
As with many industries, available capacity plays an important role in determining capital spending plans, according to industry observers. A similar pattern is evident between lagged capacity figures and petroleum refining investment in Canada, except for late 1970s (see Chart 13).[23] Capacity utilization levels may have affected investment in future years, notably the peaks in 1974 and 1982, as well as the deep trough of the mid-1980s.

[22] Note that the profit figures appearing in this chart have been lagged by two years. In other words, the lagged profit figure applicable to 1980 was the actual industry profit in 1978.

[23] The relevant capacity utilization figure is for Petroleum and Coal Products, slightly more aggregated than petroleum refining. However, petroleum refining appears to account for well over 95% of the activity of this aggregated grouping.

Chart 13

Investment and Capacity Utilization in Petroleum Refining[24]



Source: Statistics Canada, Investment and Capital Stock Division.

Important shifts in the mix of refined petroleum products demanded by customers have occurred in the past few decades. Lighter distillates now account for a larger portion of industry output than in the past. Fuel oil demand by business and consumers has declined, while total demand for refined petroleum products has slowly grown. The change in the mix of output has required significant bursts of investment by the industry in order to increase capacity of the "cracking" units that can produce lighter products.

5.2.6 Pulp and Paper

The clearly cyclical pattern of investment in the pulp and paper industry in Canada has tended to more closely match the investment pattern of the rest of the economy than many of the other industries under consideration in this study. (see Chart 14)[25] Concurrent peaks in the two series are evident in the mid 1960s, and both at the start and the end of the 1980s. Only during the 1970 to 1977 period did the industry's investment movement differ sharply from the rest of the economy. Since Canadian pulp and paper firms compete in world markets, the Ministry may also wish to monitor economic activity in

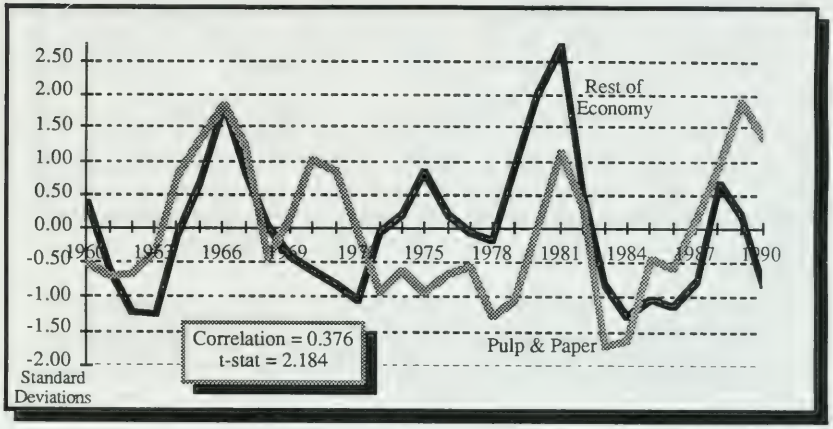
[24] The capacity utilization data in this chart are lagged by one year. In other words, the level in the chart for 1980 represents the actual utilization rate in 1979.

[25] A significant, positive relationship was found between variations from trend of investment with a correlation coefficient of 0.376 (t-value of 2.184).

the U.S., Europe, and East Asia to gain insight into future investment spending in this industry.

Chart 14

Standardized Deviations of Log of Investment from Trend (Pulp & Paper and the Rest of the Economy)

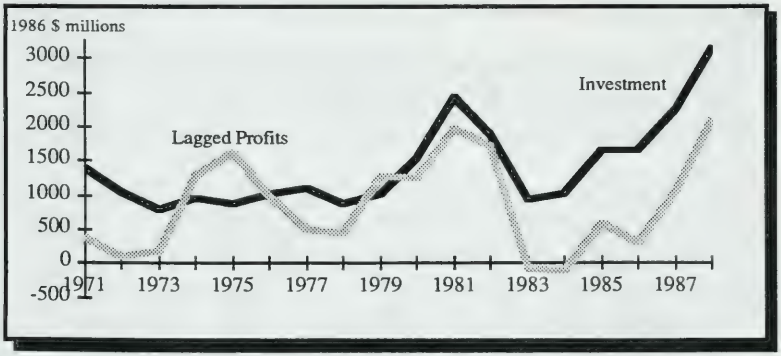


Source: Ernst & Young calculations.

Industry-Specific Factors Affecting Investment

Profits in the pulp and paper industry appear to affect investment with a one-year lag (see Chart 15). During the 1971-1988 period, the patterns of the two series matched quite closely, with the only significant deviation occurring in 1974-1975 when newsprint prices soared by nearly 50% in two years.

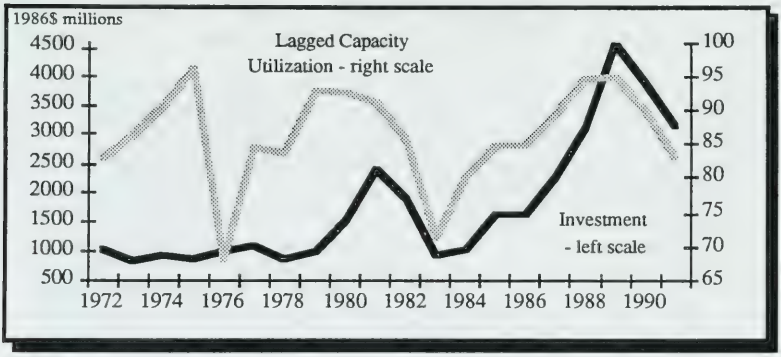
Chart 15
Investment and Profits in the Pulp and Paper Industry[26]



Sources: Statistics Canada, Investment and Capital Stock Division, and *Industry Financial Statements*, 61-207.

Capacity utilization does not seem to have had as strong an effect on industry investment as profits (see Chart 16). However, the lagged utilization pattern does seem to more closely match the investment series from the late 1970s onward.

Chart 16
Investment and Capacity Utilization in Pulp & Paper[27]



Source: Statistics Canada, Investment and Capital Stock Division.

[26] The profit figures in this chart are lagged by one year. In other words, the level in the chart for 1980 represents the actual utilization rate in 1979.

[27] Capacity utilization figures in this chart are based on the paper and allied industries, a higher level of aggregation. Pulp and paper firms account for roughly 55-60% of paper and allied activity. Capacity utilization data in this chart have been lagged one year. In other words, the lagged figure applicable to 1980 was actual utilization in 1979.

Producer prices are the main other factor thought to be important in determining industry investment, according to industry observers. Traditionally, newsprint and "market pulp"[28] prices have been the two most important indicators for the Canadian pulp and paper industry.

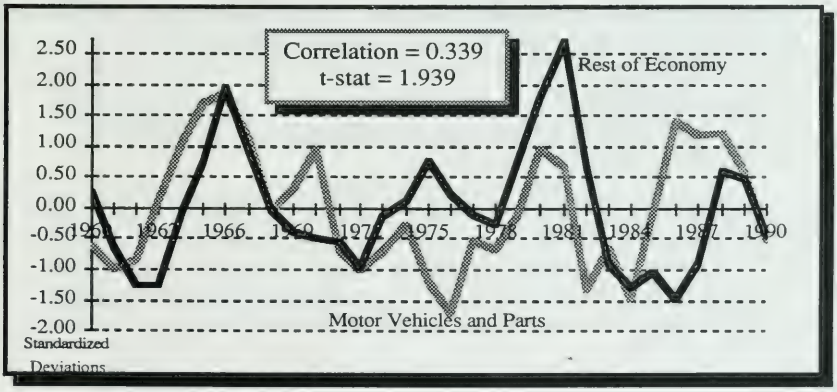
In the last decade, a significant amount of investment was undertaken by the domestic industry in machines that produce fine papers. Prices of these products may affect industry investment more strongly in the future. Other price indicators of note are Statistics Canada's industrial product price indexes for writing and reproduction paper and for other fine paper.

5.2.7 Motor Vehicle Assembly and Parts[29]

Investment in the motor vehicle and parts industry in Canada has shown a broadly cyclical path since 1960 (see Chart 17). The industry's capital spending may be somewhat related to the investment pattern of the rest of the economy.[30]

Chart 17

Standardized Deviations of Log of Investment from Trend (Motor Vehicles and Parts and the Rest of the Economy)



Source: Ernst & Young calculations.

28 Specifically, northern bleached softwood kraft (NBSK) market pulp is the price of most importance for Canadian producers.

29 The section on vehicle assembly and parts does not include a discussion of any investment cycle in metal casting and metal plating because investment data are not produced by Statistics Canada for these sectors.

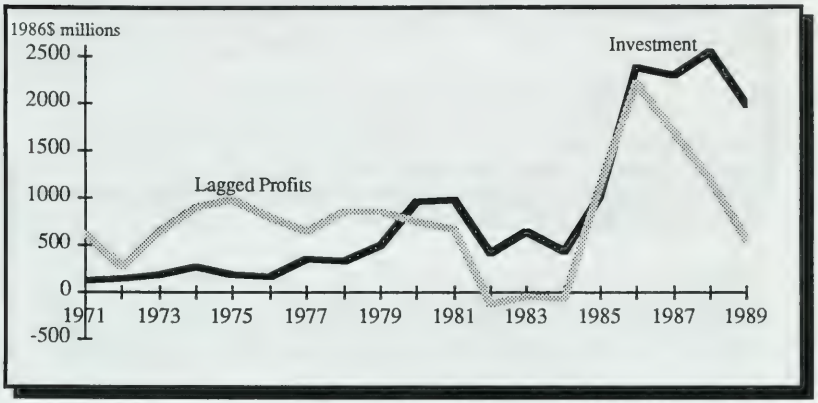
30 A correlation coefficient of 0.339 was found between the variations from trend of investment in auto assembly and in the rest of the economy (see Chart X). The t-statistic of 1.939 does not quite meet a test of significance at the 5% level.

Industry-Specific Factors Affecting Investment

Profits of vehicle and parts firms have appeared to lead the investment pattern of the industry (see Chart 18), particularly since 1979.

Chart 18

Investment and Profits in the Motor Vehicle and Parts Industry[31]



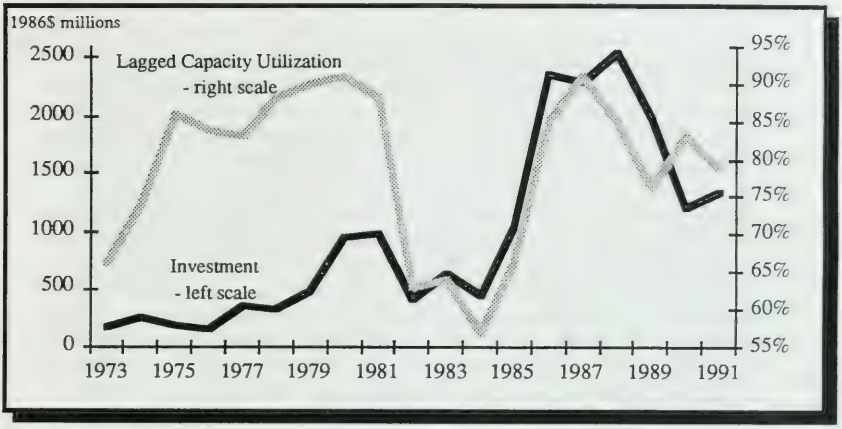
Source: Statistics Canada, Investment and Capital Stock Division; and, Statistics Canada, *Industry Financial Statements*, 61-207.

The availability of capacity in the industry seems to have become an important factor in the determination of industry investment in the mid-1970s (see Chart 19).

[31] The profit figures in this chart have been lagged by two years. In other words, the value for 1980 represents profits earned in 1978.

Chart 19

Investment and Capacity Utilization in the Motor Vehicle and Parts Industry[32]



Source: Statistics Canada, Investment and Capital Stock Division.

During the last twenty years, the share of the North American vehicles market accounted for by production from overseas, primarily Asia, has increased continuously. If this trend is maintained, less automobile assembly, and associated parts manufacturing, is likely to be done in Ontario. The Ministry may wish to keep abreast of developments in the relative market share of North American-produced cars and trucks.[33]

In contrast, the Asian "transplant" assembly facilities located in North America, such as Honda's Alliston operation, are beginning to utilize a higher share of North American-made parts. Greater investment may be seen in the parts sector if this trend continues.[34] As well, because of the integrated nature of North American vehicle and parts production, capital spending in Ontario's auto parts sector may be

---

32 Capacity utilization figures are for the aggregated transportation equipment industry. aggregated sector. The capacity utilization data is lagged by two years. In other words, the value for 1980 was the utilization figure for 1978.

33 Many North American-produced vehicles now come from plants owned by Asian and European companies. The market share of importance here is that enjoyed by overseas production facilities, whether owned by North American, Asian, or European firms.

34 Any move to raise the 50% North American content rule for motor vehicles established under the Canada-U.S. Free Trade Agreement to 60% under a trade agreement that encompasses Mexico may generate investment in the Ontario auto parts industry.

given further impetus if new "transplant" facilities are constructed anywhere on the eastern part of the continent.

5.3 Recommendations for Monitoring Investment Cycles in Ontario

In order to anticipate surges in capital spending by industries, the Ministry may wish to monitor a number of the factors that play a role in determining investment in each industry.[35] This section indicates approaches that should assist the Ministry in maintaining an awareness of the movement of industry investment expenditures.

A variety of possible approaches to monitoring investment cycles can be identified. Technical and statistical methods, such as econometric models of Canada and some of the provinces, could be used to evaluate future investment spending possibilities. However, these models may lack relevant industry detail. Broadly based surveys of investment intentions completed by Statistics Canada or industry associations are also available. As well, industry-specific discussions could be held with industry participants and observers.

As noted earlier, several significant factors tend to affect investment in all industries and should be tracked, including

- the economy-wide business cycle;
- industry profits;
- capacity utilization;
- prices received by firms for their outputs; and,
- interest rates on long-term loans and bonds.

Table 2 highlights the key factors that the Ministry should monitor to gain an understanding of future investment patterns in the industries under consideration.

Other Recommendations

Other methods to keep abreast of developments that may affect industry capital spending are:

- **reviews of Statistics Canada publications** on investment spending;

[35] Sources of information are included in Appendix 1.

- **assessing the Index of Business Confidence** that the Conference Board of Canada produces on a quarterly basis. The index can act as a leading indicator for nearer term investment spending movement in the whole economy;

- **review selected trade publications** for industries of interest to stay up-to-date on the general technological trends in each industry, which may shed light on future bursts of investment;

- **industry-specific surveys**, perhaps directed at only a few sectors each year, but looking for investment plans for the next several years. As well, expectations of inflation on the part of corporations will be required to determine the anticipated real rate of interest, since the published interest rates on corporate bonds will only be the nominal rates for the borrowing period in question. The Ministry may want to conduct periodic surveys of financial officers to gauge their views on average inflation rates over five, ten, and twenty year periods.;

- **focus groups with industry executives and/or analysts** one or twice a year to gauge business confidence as well as general investment and technological trends; and,

- **a panel of private economic forecasters** who track investment prospects in Ontario and the rest of Canada. Such a group may be better able to shed light on economy-wide investment, but less well-equipped for industry-specific forecasts.

Table 2

Summary of Key Factors Affecting Industry Investment

Industry	Factors to Monitor					
	Profits	Capacity	Prices	Economy	Technology	Other Areas
Non-Metallic Minerals				√√√	√	- commercial and industrial construction activity
Industrial Chemicals	√√			√	√	
Steel	√√	√√		√√	√√	- activity in the auto and parts industry
Mining, Refining, & Smelting	√√	√	√√		√√	– international, not only Canadian, economic activity - major mineral discoveries worldwide
Petroleum Refining	√	√√	√	√	√	- mix of product demand - environmental rules on use and nature of industry's products
Pulp & Paper	√√	√√	√	√√	√√	– international, not only Canadian, economic activity
Vehicles & Parts	√√	√		√√	√	- market share of vehicles manufactured offshore - use of North American-made auto parts by Asian "transplants"
Metal Casting	√	N/A	√	√	√	- auto and parts activity
Metal Plating	√	N/A	√	√	√	- auto assembly activity

Note:

√√√ indicates factor of great importance to industry investment pattern

√√ indicates factor of moderate importance to industry investment pattern

√ indicates factor of minor importance to industry investment pattern

Appendix 1 - Data Sources

A1. General Economic Indicators

Information on **the economy-wide business cycle** is available from a number of sources including Statistics Canada, *National Income and Expenditure Accounts,* Ministry of Treasury and Economics, Office of Economic Policy, *Ontario Economic Accounts;* and, Statistics Canada, *Provincial Economic Accounts.*

Data on **industry profits** can be obtained from either Statistics Canada, *Quarterly Financial Statistics for Enterprises,* 61-008, or Statistics Canada, *Corporation Financial Statistics,* 61-207; or Statistics Canada, Industrial Organization and Finance Division;

Capacity utilization measures are provided in Statistics Canada, *Capacity Utilization Rates in Canadian Manufacturing,* 31-003, or are obtainable from Statistics Canada, Investment and Capital Stock Division, National Wealth and Capital Stock Section.

Data on **producer prices for various products** and **price levels aggregated by industry** are available from Statistics Canada, *Industrial Product Price Indexes,* 62-011, or from the Goods and Services Producing Industries Section, in the Prices Division of Statistics Canada.

Data regarding **interest rates on long-term loans** can be obtained from the prime lending rates of the major chartered banks. Average weighted yields on **medium-term and long-term bonds** can be obtained from the investment dealer Scotia MacLeod or found in the Bank of Canada Review, Table F1.

Statistics Canada issues two publications of indicating investment spending intentions of business. *Private and Public Investment,* 61-205, and *Capital and repair expenditures, manufacturing sub-industries, intentions,* 61-214.

A.2 Industry Specific Factors

A number of industry-specific factors have been identified during the course of this study. Information sources are listed below by industry.

Non-Metallic Minerals

For **residential and construction activity**, Statistics Canada produces two publications of interest, *Building permits*, 64-001, a monthly publication giving provincial detail; and, *Construction in Canada*, 64-201, an annual publication.

Industrial Chemicals

Price indexes at the industry level for industrial inorganic and industrial organic chemicals are available from Statistics Canada, as are price indexes for commodities within the industry.

Technological change at both product and process level play an important role in industrial chemical investment. Sources for technological progress include the Canadian Chemical Producers' Association in Ottawa, the Chemical Manufacturers' Association in Washington, and the Industrial Chemical Research Association in Dearborn, Michigan. Industrial chemicals firms in Ontario such as DuPont Canada in Kingston, Polysar in Sarnia, Cyanamid Canada in Toronto, ICI Canada in Toronto, and Dow Chemical in Sarnia should also be able to provide an overview on technological changes in the chemical business.

Steel

The Ministry should be monitoring **new vehicle sales** in Ontario and elsewhere in Canada. The Motor Vehicle Manufacturers' Association of Canada provides frequent reports on new car sales. Ward's Automotive magazine is also a frequently used source for vehicle sales in Canada and the United States. Auto parts activity information may be obtained from the Automotive Parts Manufacturers' Association of Canada.

Activity in the consumer durables industry, another main buyer of Ontario steel, can be monitored using Statistics Canada, *National Income and Expenditure Accounts*, for consumer spending; and, Statistics Canada, *Monthly survey of manufacturing*, 31-001, for shipments, inventories, and orders.

Changes in technology play a considerable role in capital spending in the steel industry. The Ministry should monitor these developments through contacts with the Canadian Steel Industry Institute in Ottawa, the American Iron and Steel Institute and the Steel Manufacturers' Association in Washington, Dofasco in Hamilton, Stelco in Hamilton and Toronto, and Lake Ontario Steel in Whitby among others.

Mining, Smelting, and Refining

Metals price information can be obtained from sources such as: the Mineral Policy Sector of Energy, Mines and Resources Canada, which produces the Canadian Metal Price Index; and, the Ontario Ministry of Northern Development and Mines, Mineral Development and Lands Branch, Mines and Minerals Division.

Both the Ontario Ministry of Northern Development and Mines and Energy, Mines, and Resources (EMR) Canada would be good sources of information on **new mineral finds**. The *Canadian Minerals Yearbook* produced annually by EMR contains mineral market development summaries for the key Ontario minerals.

Mining, smelting, and refining is a global business where **technological advances** can arise anywhere in the world. The Mining Association of Canada in Ottawa, the Ontario Mining Association in Toronto, the American Mining Congress in Washington, and INCO Limited in Sudbury and Toronto, Falconbridge in Sudbury and Toronto, Noranda Minerals in Toronto, and Placer Dome in Toronto and Vancouver would be sources of information on technological change in the mining industry.

Petroleum Refining

Any review of **prices** should be concerned with the price received by refiners. The aggregated industrial product price index for "gasoline and fuel oil" as well as the more specific indexes for "motor gasoline" and "fuel oil and other fuel" are most relevant to the refining business. However, no single price is likely to drive investment, probably because a number of refined products are manufactured by the industry, and the mix of outputs changed through the period of analysis.

As noted earlier, **changes in the mix of demand** for refined petroleum products strongly affects the capital spending pattern of the industry. The Canadian Petroleum Products Institute in Ottawa would be a good source for information on the mix of products produced by refiners in Ontario and Canada, and would also be a source for information on technological advances in the industry.

Information on **technological change** would available from such sources as the American Petroleum Institute in New York, the American Independent Refiners Association in Los Angeles, and the National Refiners Association in Washington.. As well, refining firms themselves could assist the Ministry with technological issues.

Pulp and Paper

Key sources for **newsprint prices** are Pulp and Paper Week magazine and the Newsprint Information Committee, a group representing seven Canadian producer based in New York city. The Ministry may be able to keep aware of advances in **product and process technologies** in the industry through regular contact with Canadian Pulp and Paper Association in Montreal, the American Paper Institute in New York, and the Technical Association of the Pulp and Paper Industry (TAPPI) in Atlanta.

Appendix 2 – References

Auerbach, Alan J. (1984) "Taxes, Firm Financial Policy, and the Cost of Capital: An Empirical Analysis", *Journal of Public Economy*, Vol. 23, No. 1.

Donaldson, G. (1962) "In Defense of Preferred Stock", *Harvard Business Review*, Vol. 42, July-August.

Myers, Stewart and N. Majluf (1984) "Corporate Financing of Investment Decisions When Firms Have Information That Investors Do Not Have", *Journal of Financial Economics*, Vol. 13, No. 2.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (1990) *Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual.*

Appendix 3 - Interview List

List of Consulting Engineers Interviewed

Derek Elion
MacLaren Engineering
Willowdale, Ontario
756-3700 x2974

Howard Goodfellow
Goodfellow Consulting
Toronto, Ontario
858-4424

Frank Guillaume
Proctor & Redfern
Toronto, Ontario
445-3600 x2394

Richard Laughton
Pollu-Tech
Oakville, Ontario
847-0065

Orlando Martini
Giffels Engineering
Mississauga, Ontario
798-5476

Dave Mallen
Hatch Consultants
Toronto, Ontario
855-7600

Volker Masemann
Proctor & Redfern
Toronto, Ontario
445-3600 x2205

Klaus Schonfeld
Marshall Macklin Monaghan
Thornhill, Ontario
882-1100

Louis Tasfi
M.M. Dillon Ltd.
London, Ontario
519-858-2320

Tony Vander Vooren
MacLaren Engineering
Willowdale, Ontario
756-3700 x2845

Bill Walker
M.M. Dillon Ltd.
London, Ontario
519-438-6192

George Zuchovs
CH2M Hill
Toronto, Ontario
858-2320

Industry Representatives Interviewed

Industrial Chemicals

Jim Taylor
Corporate Mgr. of Environmental Affairs
DuPont Canada
613-544-6000
613-548-5297 (fax)

Bud West
Mgr. of Safety and Health
Polysar, Sarnia
519-337-8251
519-339-7723 (fax)

Neil Maclean
Environmental Specialist
ICI Canada, Cornwall
613-938-5270
613-938-5239 (fax)

Barry Rose
Environmental Affairs
Cyanamid Canada
416-374-5829
416-374-5829 (fax) Welland
or 470-3669
470-3857 (fax) Toronto

Metal Mining and Refining

Mike Sudbury
Director of Environmental Affairs
Falconbridge, Toronto
863-7276

Henry Bréhaut
Sr. Vice-President, Environmental
Placer Dome, Toronto
868-6060
868-6062 (fax)

Brian Bell
Supervisor of Environmental Control, Ontario Division
INCO, Sudbury
705-682-8341
705-682-8363 (fax)

Metal Casting

Ian Vaughan
Plant Engineer
Haley Industries, Haley Station
613-432-8841
613-432-9456 (fax)

Clive Graham
Engineering Manager
Canada Pipe, Hamilton
416-547-3251
416-547-3248 (fax)

Metal Plating

Doug Henry
Project Engineer
Butcher Engineering Enterprises, Mississauga
459-3030
459-0689 (fax)

James Sutherland
Technical Manager
Coatings 85 Ltd., Mississauga
564-1717
564-1723(fax)

Non-Metallic Minerals

John Dawson
Manager, Special Projects
Canada Brick, Toronto
821-8800
821-4554 (fax)

Mark Wallace
Environmental Engineer
St. Mary's Cement, Toronto
686-2116
623-5705(fax)

Hal Bartlett
Plant Manager
Lafarge Canada, Woodstock
519-423-6241
519-423-6414 (fax)

Colin Wobschall
Environmental Engineer
Steetley Quarry Products, Dundas
416-527-3671
416-628-3044 (fax)

Petroleum Refining

Farad Seif
Manager for Environment Safety, Central Region
Petro-Canada, Toronto
730-2016

Jim Greenshields
Purchasing Dept.
Sunoco, Sarnia
519-337-2304
519-332-3309 (fax)

Pulp and Paper

Bob Coleman
Environment Department
Abitibi-Price
369-6739
369-6794 (fax)

Yvon Beauregard
VP, Environment
Domtar, Montreal
514-848-5176
514-848-6558 (fax)
Montreal

Wally Vrooman
VP, Environment
CP Forest Products, Thunder Bay
807-475-2652
807-475-4801 (fax)

Steel

Hugh Eisler
General Mgr. of Environmental Control
Stelco, Hamilton
367-1450 x3621
416-577-4441 (fax)

Tom McGuire
Environmental Coordinator, Water Mgmt.,
Dofasco, Hamilton
416-544-3761 x 6766
416-548-4263 (fax)

Andrew Connor
Residuals Coordinator, Environment Control Dept.
Dofasco, Hamilton
416-544-3761 x 6763
416-548-4263 (fax)

Brent Steele
Environmental Specialist, Environmental Control Dept.
Dofasco, Hamilton
416-544-3761 x 6768
416-548-4263 (fax)

Transportation Equipment

Ron Bright
Director of Environmental Control & Vehicle Safety
Ford Canada, Oakville
845-2511
844-1198(fax)

Bill Hockett
Senior Staff Assistant, Office of the Environment
GM Canada, Oshawa
416-644-2364

List of Industry Follow-Up Interviews

Industrial Chemicals

Barry Rose
Cyanamid Canada
416-374-5829 or 470-3669

Jim Taylor
DuPont Canada
613-544-6000

Metal Casting

James Cunningham
Cunningham Foundry
St. Catherines
416-685-6577

John Williams
Engineering Manager
Alcan Automotive Castings
St. Catherines
416-984-3515

Ian Vaughan
Haley Industries
613-432-8841

Mining/Smelting/Refining

Mike Sudbury
Falconbridge
863-7276

Non-Metallic Minerals

Colin Wobschall
Steetley Quarry Products
416-527-3671

Petroleum Refining

Farad Seif
Petro Canada
730-2016

Pulp & Paper

Yvon Beauregard
Domtar
514-848-5176

Steel

Hugh Eisler
Stelco
367-1450 x4070

List of Finance Executives Interviewed

Bill Barley
Vice-President & Treasurer
DuPont Canada
821-5358

Ken Bowman
Manager, Corporate Finance
Imperial Oil
968-4111

Bill Hayes
Vice-President & Treasurer
Placer Dome
604-682-7082

Lars-Eric Johannsen
Senior Vice-President & CFO
Falconbridge
863-7000

Jim Lemenchick
Vice-President - Finance
Haley Industries
613-432-8841 x242

Paul Matthews
Vice-President & Treasurer
Stelco
362-2161

Eileen Mercier
Senior Vice-President & CFO
Abitibi-Price
369-6718

Anthony Sabatini
Vice-President & Treasurer
INCO
361-7511

Bill Solski
Vice-President, Finance
Dofasco
416-544-3761

Industry Observers Interviewed

Fiona Cook
Economist
Canadian Pulp & Paper Association
Montreal, Quebec
514-866-6621
514-866-3035 (fax)

Bob Keyes
Vice-President, Economic Affairs
Mining Association of Canada
Ottawa, Ontario
613-233-9391
613-233-8897 (fax)

Kevin McElhatton
Vice-President & Economist
Canadian Pulp & Paper Association
Montreal, Quebec
514-866-6621
514-866-3035 (fax)

Steve Stinson
Industry Economist
Royal Bank of Canada
Montreal, Quebec
514-874-3891

Mike Tremblay
Industry Economist
Royal Bank of Canada
Montreal, Quebec
514-874-5140
(Petroleum Refining, Industrial Chemicals)

Carlos Leitao
Industry Economist
Royal Bank of Canada
Montreal, Quebec
514-874-6732

Art Leneveu
Canadian Chemical Producers' Association
Ottawa, Ontario
613-237-6215
613-237-4061 (fax)

Appendix 4 - Data Presented in Graphs

	Chart 1		Chart 2		Chart 3	
	Non-Metallic Minerals	Rest of Economy	Industrial Chemicals	Rest of Economy	Investment in Chemicals	Lagged Profits in Chemicals
1960	-0.784	0.286	-0.737	0.336		
1961	-1.220	-0.641	-0.457	-0.652		
1962	-0.880	-1.247	-1.111	-1.194		
1963	-1.000	-1.199	-0.833	-1.174		
1964	0.108	0.038	-0.696	0.129		
1965	0.731	0.845	0.391	0.874		
1966	1.713	2.003	0.239	2.142		
1967	0.808	0.952	0.200	1.007		
1968	-0.128	-0.050	0.899	-0.174		
1969	0.665	-0.405	0.033	-0.365		
1970	0.766	-0.419	0.009	-0.372	495.1	37.0
1971	-0.811	-0.569	-0.580	-0.543	391.4	41.3
1972	0.382	-1.035	-1.081	-0.922	322.8	18.8
1973	0.012	-0.195	-0.815	-0.109	386.1	45.1
1974	-0.503	0.113	0.471	0.051	757.4	71.4
1975	0.491	0.661	1.463	0.483	1287.6	151.0
1976	0.816	0.052	1.707	-0.191	1523.9	119.5
1977	0.860	-0.200	1.736	-0.458	1625.6	123.5
1978	0.748	-0.368	1.499	-0.579	1523.4	118.3
1979	1.409	0.683	0.783	0.678	1132.2	112.7
1980	0.709	1.847	-0.002	1.932	813.5	266.5
1981	0.594	2.719	1.620	2.600	1878.4	287.3
1982	-1.764	0.578	1.355	0.375	1736.5	417.7
1983	-2.340	-0.920	0.678	-1.062	1315.1	77.7
1984	-1.793	-1.389	-0.791	-1.357	678.4	158.0
1985	-1.149	-1.018	-1.263	-0.930	567.4	171.4
1986	-0.298	-1.186	-0.831	-1.110	735.4	-9.5
1987	-0.195	-0.689	-1.401	-0.561	586.7	-1.0
1988	0.336	0.772	-1.452	0.940	601.7	556.7
1989	0.892	0.530	-0.615	0.661	949.3	
1990	0.825	-0.551	-0.420	-0.457		

	Chart 4		Chart 5		Chart 6	
	Steel	Rest of Economy	Investment in Steel	Lagged Cap. Utilization	Investment in Steel	Lagged Profits
1960	0.110	0.206				
1961	-1.437	-0.552				
1962	-0.252	-1.285				
1963	-0.354	-1.222				
1964	0.967	-0.116				
1965	0.362	0.855				
1966	0.828	2.034				
1967	-0.460	1.062				
1968	-1.846	0.104				
1969	-0.939	-0.267				
1970	0.473	-0.419			673.9	98.3
1971	0.267	-0.620			626.0	142.5
1972	0.277	-1.034	634.0	0.880	634.0	154.0
1973	0.499	-0.229	699.0	0.893	699.0	131.1
1974	1.220	-0.024	941.6	0.946	941.6	200.9
1975	1.574	0.527	1094.7	0.976	1094.7	290.4
1976	0.599	0.052	747.0	0.855	747.0	202.0
1977	0.432	-0.182	704.8	0.765	704.8	124.5
1978	-0.314	-0.300	527.4	0.826	527.4	174.5
1979	-0.011	0.759	600.6	0.863	600.6	334.4
1980	0.645	1.846	787.9	0.786	787.9	471.3
1981	1.270	2.668	1021.1	0.718	1021.1	324.6
1982	0.142	0.544	655.6	0.759	655.6	446.9
1983	-2.409	-0.866	237.9	0.559	237.9	-91.2
1984	-2.551	-1.326	226.8	0.634	226.8	-9.3
1985	-0.307	-1.025	562.0	0.788	562.0	156.9
1986	1.142	-1.273	1013.6	0.834	1013.6	337.2
1987	0.553	-0.726	807.5	0.796	807.5	209.0
1988	-0.365	0.793	563.6	0.873	563.6	380.3
1989	-0.208	0.557	605.7	0.948	605.7	
1990	0.094	-0.540	689.6	0.923		
1991			621.9	0.827		

	Chart 7		Chart 8		Chart 9	
	Mining/Smelt'g Refining	Rest of Economy	Investment in M/S/R	Lagged Prices	Investment in M/S/R	Lagged Profits
1960	-1.499	0.606				
1961	-1.531	-0.343	847.8	78.0		
1962	-0.223	-1.250	1181.6	79.0		
1963	-1.210	-0.964	1009.8	83.2		
1964	-0.548	0.204	1285.7	84.2		
1965	-0.862	1.117	1179.7	106.6		
1966	1.190	1.886	1984.5	119.5		
1967	1.253	0.709	2122.7	121.5		
1968	1.317	-0.412	2237.5	106.2		
1969	1.272	-0.717	2277.0	112.1		
1970	1.355	-0.748	2419.6	119.5		
1971	2.027	-1.237	3081.4	116.4	3081.4	2015.6
1972	0.513	-1.143	2199.8	100.0	2199.8	2139.0
1973	-0.197	-0.128	1954.3	101.1	1954.3	1517.1
1974	-0.205	0.165	1952.0	151.1	1952.0	1057.8
1975	-0.423	0.795	2015.4	167.7	2015.4	2752.7
1976	-0.110	0.136	2285.9	121.5	2285.9	2523.3
1977	0.157	-0.173	2479.5	111.0	2479.5	1382.7
1978	-1.669	-0.039	1654.0	110.3	1654.0	1350.2
1979	-0.989	0.933	2065.2	113.6	2065.2	1831.4
1980	0.844	1.746	3381.6	155.6	3381.6	2418.0
1981	1.483	2.491	4173.2	178.9	4173.2	4048.1
1982	0.787	0.407	3687.0	134.8	3687.0	4323.6
1983	0.121	-0.986	3261.8	104.5	3261.8	2647.6
1984	0.020	-1.433	3291.2	107.0	3291.2	-284.4
1985	-0.177	-1.006	3250.3	101.1	3250.3	83.9
1986	-1.191	-0.993	2641.2	97.4	2641.2	-609.9
1987	-1.070	-0.518	2826.5	93.7	2826.5	-660.2
1988	-0.311	0.838	3542.4	104.6	3542.4	48.4
1989	-0.071	0.573	3967.4	137.6	3967.4	1481.4
1990	-0.057	-0.515	4191.6	132.9	4191.6	
1991			3987.1	110.0	3987.1	

	Chart 10		Chart 11		Chart 12	
	Investment in Mining only	Lagged Cap. Utilization	Petroleum Refining	Rest of Economy	Investment in Petro Refining	Lagged Profits
1960			0.125	0.283		
1961			-1.187	-0.528		
1962			0.162	-1.219		
1963			-0.766	-1.093		
1964			-2.151	0.215		
1965			-1.380	0.986		
1966			-0.460	2.106		
1967			0.146	0.978		
1968			0.583	-0.095		
1969			0.530	-0.394		
1970			1.538	-0.569		
1971			1.132	-0.718	744.6	870.0
1972			1.032	-1.107	736.7	997.0
1973			1.215	-0.336	840.0	1103.0
1974			1.391	-0.085	955.1	1258.0
1975	1880.7		1.112	0.531	863.7	1674.0
1976	2154.5	0.735	0.341	0.043	610.8	1976.0
1977	2230.3	0.789	0.241	-0.193	604.3	1626.0
1978	1473.6	0.762	-0.342	-0.318	469.5	1723.0
1979	1826.7	0.792	-0.820	0.747	384.4	1518.0
1980	2815.6	0.910	-0.729	1.826	418.6	1600.0
1981	3529.9	0.970	0.972	2.539	1021.5	2671.0
1982	3161.5	0.829	1.417	0.339	1328.4	2632.0
1983	2888.1	0.707	0.541	-1.024	891.1	2018.0
1984	2598.4	0.697	-0.921	-1.359	445.5	1228.0
1985	2303.9	0.870	-1.574	-0.964	334.2	379.0
1986	2058.1	0.881	-1.331	-1.120	392.8	1883.0
1987	2311.2	0.810	-0.407	-0.689	649.4	789.0
1988	2729.2	0.868	-0.463	0.735	656.9	3409.0
1989	2463.8	0.938	0.054	0.482	885.7	1465.0
1990	2024.6	0.882				
1991	1815.9	0.865				

	Chart 13		Chart 14		Chart 15	
	Investment in Petro Refining	Lagged Cap. Utilization	Pulp & Paper	Rest of Economy	Investment in Pulp & Paper	Lagged Profits
1960			-0.523	0.372		
1961			-0.689	-0.600		
1962			-0.660	-1.225		
1963			-0.304	-1.242		
1964			0.794	-0.098		
1965			1.304	0.676		
1966			1.850	1.843		
1967			1.190	0.825		
1968			-0.422	0.028		
1969			0.152	-0.398		
1970			1.015	-0.601		
1971	744.6		0.844	-0.800	1398.3	393.3
1972	736.7	0.747	-0.056	-1.047	1058.8	85.3
1973	840.0	0.676	-0.923	-0.056	811.2	181.6
1974	955.1	0.930	-0.600	0.204	952.6	1297.2
1975	863.7	0.882	-0.926	0.856	886.0	1610.5
1976	610.8	0.891	-0.683	0.206	1011.0	1002.4
1977	604.3	0.793	-0.558	-0.073	1105.6	509.4
1978	469.5	0.962	-1.271	-0.172	895.1	447.9
1979	384.4	0.869	-1.049	0.929	1013.9	1264.4
1980	418.6	0.728	-0.012	1.988	1537.7	1237.9
1981	1021.5	0.731	1.144	2.717	2434.3	1970.5
1982	1328.4	0.853	0.330	0.536	1900.4	1713.1
1983	891.1	0.771	-1.739	-0.790	946.2	-59.4
1984	445.5	0.752	-1.631	-1.280	1028.8	-93.9
1985	334.2	0.768	-0.423	-1.018	1658.9	581.8
1986	392.8	0.777	-0.568	-1.153	1646.9	310.8
1987	649.4	0.804	0.185	-0.739	2256.0	1041.0
1988	656.9	0.879	0.977	0.684	3133.7	2081.9
1989			1.912	0.219		
1990			1.340	-0.793		

	Chart 16		Chart 17		Chart 18	
	Investment in Pulp & Paper	Lagged Cap. Utilization	Vehicles & Parts	Rest of Economy	Investment in Vehicles/Parts	Lagged Profits
1960			-0.611	0.280		
1961			-0.973	-0.648		
1962			-0.823	-1.241		
1963			0.144	-1.257		
1964			1.106	-0.048		
1965			1.702	0.721		
1966			1.862	1.936		
1967			1.091	0.910		
1968			-0.035	-0.044		
1969			0.321	-0.385		
1970			0.964	-0.469		
1971	1398.3		-0.701	-0.544	60.5	622
1972	1058.8	0.829	-1.004	-0.938	85.6	266
1973	811.2	0.863	-0.697	-0.131	102.7	647
1974	952.6	0.907	-0.265	0.132	147.7	904
1975	886.0	0.962	-1.177	0.777	113.0	979
1976	1011.0	0.684	-1.684	0.208	106.8	799
1977	1105.6	0.846	-0.520	-0.102	252.8	648
1978	895.1	0.836	-0.666	-0.265	127.3	846
1979	1013.9	0.930	-0.109	0.780	158.2	851
1980	1537.7	0.928	0.963	1.802	174.2	756
1981	2434.3	0.912	0.667	2.722	318.0	673
1982	1900.4	0.857	-1.302	0.668	221.5	-117
1983	946.2	0.713	-0.621	-0.895	503.5	-46
1984	1028.8	0.800	-1.478	-1.294	273.7	-68
1985	1658.9	0.848	-0.050	-1.027	685.6	1134
1986	1646.9	0.848	1.404	-1.454	1908.6	2193
1987	2256.0	0.894	1.182	-0.885	1527.7	1684
1988	3133.7	0.947	1.238	0.620	1889.9	1175
1989			0.594	0.510	1388.0	566
1990			-0.524	-0.442		

Chart 19

	Investment in Vehicles/Parts	Lagged Cap. Utilization
1973	102.7	0.660
1974	147.7	0.740
1975	113.0	0.860
1976	106.8	0.840
1977	252.8	0.830
1978	127.3	0.880
1979	158.2	0.900
1980	174.2	0.910
1981	318.0	0.880
1982	221.5	0.630
1983	503.5	0.640
1984	273.7	0.570
1985	685.6	0.660
1986	1908.6	0.850
1987	1527.7	0.910
1988	1889.9	0.850
1989	1388.0	0.760
1990	747.3	0.830
1991	850.7	0.790